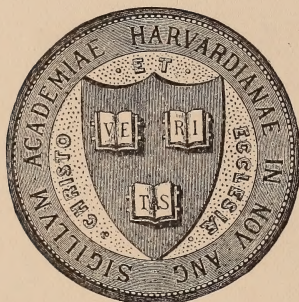


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JOURNAL & PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

EDITED BY

THE HONORARY SECRETARIES.

JUN 16 / 1892.

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THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE OPINIONS EXPRESSED THEREIN.

SYDNEY:

PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH.

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JOURNAL
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PROCEEDINGS
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ROYAL SOCIETY
OF
NEW SOUTH WALES,
FOR
1891.

INCORPORATED 1881.

VOL. XXV.

EDITED BY
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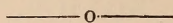
NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia," after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

NOTICE TO AUTHORS.

The Honorary Secretaries request that authors of papers (to be read before the Royal Society of New South Wales) requiring illustrations by photo-lithography, will before preparing such drawings make application to the Assistant Secretary for patterns of the standard sizes of diagrams &c. to suit the Society's Journal.

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The Royal Society of New South Wales.

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ANNIVERSARY ADDRESS.

By A. LEIBIUS, Ph. D., M.A., F.C.S.,

Senr. Assayer to the Sydney Branch of the Royal Mint.

[*Delivered to the Royal Society of N.S.W., May 6, 1891.*]

AT the last anniversary meeting of this Society you did me the honour of electing me your President for the Society's year 1890-91. To day it becomes my duty, according to old custom, to address you in the first place on matters more immediately connected with the affairs of our Society and its doings during the past year, after which I propose to bring under your notice, in a condensed form, some matters in applied science, which have special reference to our Colony. In attempting this I must crave your indulgence, feeling as I do my inability to treat the subject in hand in that complete manner which I myself would like.

This is our Seventieth Anniversary Meeting, counting from the inauguration of the Philosophical Society of Australasia in 1821, from which this Society sprung. The first general meeting under our present name of the Royal Society of N.S.W. was held on the 9th of July 1867, when that great man, whose memory will never be forgotten, the late Rev. W. B. Clarke gave his inaugural address under the presidency of the then Governor Sir John Young.

It is a matter of congratulation that to-day we occupy as the senior scientific Society of Australasia, a position which may fairly be called satisfactory, and which justifies the hope that it will go on increasing, not only in the number of its members but also in the number of valuable papers brought forward at our monthly meetings.

Financial position.—From the statement of our Honorary Treasurer, submitted to you this evening, you will perceive that our total income for the past financial year was £1,265 11s. 7d., being an increase of £45 on the receipts of the previous twelve

months. The expenditure was £1,268 11s., showing also an increase of £88 on the total of the year before, chiefly due to the holding of the *Conversazione* and to the extra cost of printing and publishing the Society's Journal. There was a cash balance of £41 12s, to the credit of the General Account at the end of the year while there were no liabilities ; but it should be mentioned, that owing to the heavy expenditure the amount received for entrance fees during the last two years, amounting to £65 2s. has not been transferred to the Building and Investment Account, according to previous practice. The Building and Investment Fund now amounts to £566 17s. 1d., and the Clarke Memorial Fund to £300 1s. 8d., which is invested on fixed deposit at the Union Bank for twelve months at five per cent.

It is the intention some day to use this Building and Investment Fund, together with the proceeds from the sale of our present property, should a favourable opportunity for doing so arrive, towards the cost of acquiring larger and more suitable premises, especially on account of our increasing Library and the desirability of providing comfortable reading rooms and other offices. To obtain this desirable change may take years, yet the Council is keeping it steadily in view.

One of our aims now, and for some years past, has been the acquisition of a good scientific Library. We are therefore spending yearly a considerable portion of our income in the acquisition of books in all branches of science and of some of the best scientific periodicals—English, French, and German. We may fairly claim to possess already the best and most complete sets of scientific publications in the Colonies. During last year we expended in the purchase of :

Scientific books	£46	6	10
Scientific periodicals	£63	15	5
Back numbers of scientific serials to complete the sets where possible	£42	12	0
For book binding	£93	16	7

During the last ten years the expenditure on books and periodicals

has amounted to £2,277 2s. 7d., and for binding to £461 10s. 5d.
Total £2,738 13s.

Since 1886 the Government has ceased to print and publish the Journal and Proceedings of our Society, but have increased the grant from £400 to £500 per year.

The cost of these publications has been as under viz. :—

In 1887	...	...	...	£210	1	8
1888	...	...	...	£246	6	0
1889	...	...	...	£257	4	6
1890	...	...	...	£316	3	5

so that we are losers to the extent of from £100 to £200 per year by this change in the arrangement.

Roll of Members.—The number of members on the roll on 30th April last was 457 besides 18 honorary and 2 corresponding members. Twenty-five new members were elected during last session, and 29 candidates are at present awaiting election, while 9 members resigned and thirteen ceased to be members on account of non-payment of their subscriptions. We have also to regret the loss by death of one honorary, one corresponding, and eight ordinary members viz. :—

	Elected.	Died.
<i>Honorary Member:</i> Dr. Schomburgk,	1875,	Mar. 24, 1891
<i>Corresponding Member:</i> Dr. O. Feistmantel,	1883,	Jan. 10, 1891
<i>Ordinary Members:</i> Atherton, Eben., M.R.C.S.	1873,	Sep. 22, 1890
Black, Morrice Alexander, F.I.A.	1878,	Aug. 27, 1890
Conder, W. J.	1876,	Dec. 1, 1890
Grahame, The Hon. William, M.L.C.	1876,	Nov. 26, 1890
Latta, G. J.	1874,	Jan. 7, 1891
Stephens, Professor W. J., M.A., <i>Oxon.</i> ,	1857,	Nov. 22, 1890
Street, J. R., M.L.A.	1878,	Mar. 23, 1891
White, The Hon. James, M.L.C.	1875,	July 13, 1890

DR. RICHARD SCHOMBURGK was the son of the late Rev. J. F. L. Schomburgk, a Lutheran Minister. He was born at Fribault in Saxony, on the 5th October, 1811. Making a special study of Botany he was for a time connected with the Royal Gardens at

Potsdam, and later on sought the tuition of his famous brother, Sir Robert, who had already distinguished himself in the world of travel, more especially in connection with Baron von Humboldt. One of his chief expeditions was made with his brother Sir Robert in 1840, when the latter went to British Guiana to effect the demarcation of the boundaries of that colony. After his return he took an active part in the political agitation of the time and was eventually compelled to leave the country. In company with his brother Otto he came to South Australia, and at Buchsfelde on the Gawler River, commenced farming and viticulture, residing there for ten years, during portion of which time he was Curator of the Gawler Museum. In 1866 Dr. Schomburgk was offered and accepted the Directorship of the Adelaide Botanic Gardens, which position he held to the time of his death on the 24th March, 1891. With great enthusiasm and his extensive knowledge he succeeded in making the Adelaide Botanic Gardens the admiration of all who saw them. During many years of devotion to Botany he has made for himself a world wide reputation and has contributed many additions to the stores of science. He was the author of various papers on the culture of tobacco, sugar, millet, flax, hemp, beetroot, hops, raisins, almonds, and other plants. His special delight was the study of new plants, and to obtain them he went to great trouble in getting new seeds in exchange for Australian plants, and when his own experiments with them were successful, he would distribute seeds and plants amongst farmers and gardeners in all parts of South Australia, asking only as a return that reports might be sent to him as to the results obtained by the recipients.

In his private character Dr. Schomburgk made himself beloved by everyone by his simple genuine kind nature. Though possessing an extraordinary long list of titles and degrees, conferred upon him by foreign Governments and scientific societies in all parts of the world, he was the most unassuming of men. No one ever applied to him in vain for information even in his busiest hours. Every spare moment was spent in the Museum of Economic Botany

in what he regarded as a labour of love, and although only organized a few years ago, it is already one of the most popular attractions at the Adelaide Gardens. He also took great interest in exploration, and was a member of the Council of the South Australian Branch of the Royal Geographical Society. The death of such a man will be a great loss to scientific as well as social circles.

Dr. OTTOKAR FEISTMANTEL held at the time of his death, on January 10th last, the appointment of Professor of Geology and Palæontology at the Polytechnicum in Prague. In 1876 he joined the Geological Survey Service of India as Palæontologist, which he left in 1883 on furlough, resigning however, eventually in 1885 (without having returned to India) on accepting the before mentioned Professorship in Prague. His work in India was almost wholly Palæo-botanical, and is represented by numerous papers on the "Records of the Geological Survey of India," and four magnificent volumes of the "Palæontologia Indica," relating to the "Fossil-Flora of the Gondwana System in India," commencing about 1877 and reaching completion in 1886. Therein are described and compared the whole of the Mesozoic Coal Flora of India and its relation to outside areas pointed out.

Amongst us, however, Dr. Feistmantel's name will always be remembered in connection with his "Palæozoische und Mesozoische Flora des oestlichen Australiens," published in the "Palæontographica" for 1878-79, (Suppl. Bd. III., Lief. 3) in which he described the fossil plants collected during the life-long explorations of the late Rev. W. B. Clarke, F.R.S., supplemented by others, contributed by Mr. C. S. Wilkinson, F.G.S., Government Geologist for N.S.W. An epitome of this work appeared in the Geological Magazine for 1879 (Dec. 2, Vol. VI.,) and in the Journal of the Royal Society of New South Wales (Vol. XIV., pro 1880, pp. 103 - 118) under the title of "Notes on the Fossil Flora of Eastern Australia and Tasmania." This important paper was read before this Society by Mr. C. S. Wilkinson at the meeting held here on Aug. 4th, 1880.

The full work on these fossils has lately been amplified by himself and published in English as one of the "Memoirs of the Geological Survey of New South Wales," (Pal. Series, Mem. No. 3). His loss is greatly to be regretted and will be much felt in that branch of science in which he worked so long and earnestly.

Mr. WILLIAM JACOMB CONDER became a member of this Society in 1876 and held a seat on the Council during 1884-85. He arrived in Victoria in 1851 where he became a Surveyor, changing his residence in 1864 to New South Wales. Here he soon became known as a very able officer in the Survey Department, which led to his promotion as Chief Trigonometrical Surveyor in 1876. On the discontinuance of the trigonometrical survey in 1883, Mr. Conder was appointed chairman of a commission to enquire into and report upon District Survey Offices in the Colony, and in 1885 he was made Chairman of the Cooma Land Board. In May 1882 he was sent to Lord Howe Island to lay the basis of correct surveys in that island, and in December of that year he conducted the Transit of Venus party to the same place, both of which commissions he carried out most successfully. Mr. Conder died after a prolonged and severe illness on December 1st 1890, at the age of 59.

Mr. G. J. LATTA arrived in Victoria from England in 1860 as an assayer, and became in 1861 Chemist to the Port Phillip Company at Clunes, when he devised a process for profitably treating auriferous pyrites. In 1864 he settled in Sydney as manager of the Pyrmont Tin Smelting Works, of which he was also a partner. Mr. Latta was elected a member of this Society in 1874, and read an interesting paper in October of that year, on "Iron pyrites" before this Society. Mr. Latta was 71 years of age at the time of his death in January last.

By the death of Professor STEPHENS, M.A., F.G.S., the Colony sustained a very great loss, and in referring to it I cannot do better than extract some passages from the able address given to the Linnean Society of N.S.W., on January 28th last, at their

annual meeting by their Vice-President Dr. J. C. Cox : “. . . Mr. William John Stephens, M.A., *Oxon.*, came to this Colony in the year 1856, at the age of 27, to assume the Headmastership of the Sydney Grammar School, which had just been founded, to the position of which he had been elected on the recommendation of Dr. Jowett. After ten years work at the Grammar School he resigned his headmastership and established a school of his own in Darlinghurst Road, which was known as the “New School,” and afterwards as “Eaglesfield.” This school he continued to conduct till his appointment in 1882 to the Professorship of Natural History at the Sydney University, the title of which was afterwards changed, upon a redistribution of work on the foundation of certain additional Chairs, to that of Geology and Palæontology.

“For a period of nearly 35 years then Professor Stephens lived in our midst, labouring uninterruptedly in the cause of higher education, yet finding time and inclination to give the Colony at large the benefit of his extensive knowledge and experience by his connection with several of our important public institutions, such as the Public Library, of which he was Chairman of Trustees, and the Australian Museum, of which he was a member of the Board. For a time also he was President of the Sydney Branch of the Geographical Society of Australasia. In his favourite pursuit of Natural Science he was actively identified, firstly with the Entomological Society of New South Wales, and afterwards with its successor the Linnean Society of New South Wales, dating from its inception, having been a member of Council during the years 1875-76, President in 1877-78, Vice-President in 1879-80, Co-Honorary Secretary in 1881-84, and again President from 1885 to the close of his life in November 1890. His contributions to the Proceedings of the Linnean Society of N.S.W. include seven Presidential addresses in addition to a number of important papers bearing on Geology and allied subjects.”

Professor Stephens was in 1857, a member of the Philosophical Society of N.S.W., the forerunner of this Society and for a time one of its Hon Secretaries. In this capacity he edited the volume

of Transactions of the Philosophical Society of N.S.W., published by the Society in 1866. This volume contains a selection of papers read before the Society between 1862 - 1865. Since then Professor Stephéns took no active part in our Society of which he was however a member to the time of his decease, his spare time being chiefly occupied with the affairs and progress of the former Entomological and the present Linnean Society as stated in the foregoing.

Papers read before the Society.—The following is a list of papers read during last year :—

1890.

May 7. 1—Presidential Address. By Prof. Liversidge, M.A., F.R.S.

June 4. 2—On a compressed-air Flying-machine. By Lawrence Hargrave.

„ 3—On the treatment of Slips on the Illawarra Railway at Stanwell Park. By Walter Shellshear, A.M.I.C.E.

„ 4—On Native names of some of the Runs &c. in the Lachlan District. By F. B. W. Woolrych.

„ 5—Remarks on a new Plant rich in tannin. By Charles Moore, F.L.S.

*July 2	{	6—Record of hitherto undescribed Plants from Arnheim's Land. By Baron Ferd. von Mueller, K.C.M.G., M. and Ph.D., F.R.S., &c.
Aug. 6.		
Sept. 3.		
Nov. 5.		

Aug. 6. 7—The Theory of the Repetition of Angular Measures with Theodolites. By G. H. Knibbs.

„ 8—On some Photographs of the Milky Way, recently taken at Sydney Observatory. By H. C. Russell, B.A., C.M.G., F.R.S.

„ 9—Australian Aborigines : varieties of food and methods of obtaining it. By W. T. Wyndham.

* In this paper the Baron was pleased to name one of the plants described after your President, "*Tylophora Leibiana*."

- Sept. 3. 10—On the application of the results of testing Australian timbers to the design and construction of timber structures. By Prof. Warren, M. Inst. C.E., Wh. Sc.
- Oct. 1. This evening was occupied with the Discussion upon Prof. Warren's paper, read at the previous meeting.
- Nov. 5. 11—Geological Notes on the Barrier Ranges Silverfield. By C. W. Marsh.
- „ 12—Some Folk Songs and Myths from Samoa by Rev. T. Powell and Rev. G. Pratt, with an Introduction and Notes by Dr. John Fraser, B.A.
- Dec. 3. 13—The Coal Fields of New South Wales and their associated Eruptive Rocks. By T. W. Edgeworth David, B.A., F.G.S.
- „ 14—Some remarks on the Australian Languages, By Dr. John Fraser, B.A.
- „ 15—On the 74oz. Compressed-air Flying-machine. By Lawrence Hargrave.

In addition to papers read at the Monthly General Meetings the following is a list of exhibits shown at some of those meetings. They were accompanied with explanatory remarks which greatly added to the interest shown in the same :

1890.

- June 4—C. Moore, F.L.S., Two new filmy ferns.
- „ H. C Russell, B.A., F.R.S., Meteoric Iron weighing over 70 lbs., found on the Narraburra Creek in 1854.
- „ Prof. Anderson Stuart, M.D., Demonstration of the working of the valves of the heart through plate glass windows tied into the walls of the right auricle and ventricle.
- July 2—Prof. Anderson Stuart, A new mode of demonstrating the manner in which the mind judges of the position of objects in the outer world.

July 2—Prof. Anderson Stuart, Working models demonstrating the value of the spinal curves in diminishing the evil effects of mechanical violence.

„ Rev. Robert Harley, M.A., *Oxon.*, F.R.S., Charles, Third Earl Stanhope's Arithmetical Machine, bearing date 1780, also his Demonstrator, an instrument for the performance of logical operations.

Sept. 3—Prof. Threlfall, M.A., Enlargement of a negative of Fresnel's Interference bands, for lecture purposes.

„ C. L. Garland, M.L.A., Edison's latest perfected Phonograph.

Nov. 5—H. C. Russell, B.A., C.M.G., F.R.S., Some of the surprising Star photographs recently taken at Sydney Observatory.

Attendance of Members.—It is gratifying to record here that the attendance of members and visitors at our eight monthly meetings last year has been very good, and a vast improvement on former years, which I sincerely hope may be maintained during the current year. It is an encouragement to those of our members who are able and willing to produce papers for our monthly meetings to know that they will have good audiences to listen to, and—still better—to discuss their papers.

I look forward to a large increase in the number of working members in the near future, when the splendid educational advantages which this colony now offers, both through the University and the Technical College, have produced their anticipated results.

Clarke Medal.—At the meeting of the Council on the 26th November last, it was unanimously resolved that the Clarke Memorial Medal for 1891 be awarded to Professor F. W. Hutton F.G.S., Canterbury College, Christchurch, New Zealand, in recognition of his long continued scientific labours and more particularly on account of his invaluable contributions to the geology and natural history of New Zealand.

Library and Exchanges.—As stated already we are endeavouring to increase our Library, both by the purchase of books and

by exchanges of our own publications with other Societies. That these are much appreciated is in evidence by the applications constantly received from Scientific Societies in all parts of the World for entering into an "Exchange-relationship" with them, asking also, not unfrequently for the back numbers of our Journal. The latter however, we are unable to supply in full, owing to many volumes being out of print.

The donations during last year consisted of 450 volumes, 1235 parts, 216 pamphlets, 19 hydrographic charts, 241 meteorological charts, 13 photographs, 2 micro-photographs, 4 geological maps, 1 atlas of plates and 3 atlases of maps—total 2184 publications.

To complete scientific series the following were *purchased*:—1. Transactions of the Royal Society of Edinburgh, Vols. I. -- XXVIII., 1788–1879. 2. Bulletin of the Royal Academy of Sciences, Letters and Fine Arts of Belgium, 1st Series, Tome I. – XXIII. ; 2nd Series, Tome I. – XL., from 1832–1875.

By Presentation we were able to complete: 1. Transactions of the Asiatic Society of Japan, Vols. I. – XVIII., 1872–89. 2. Verhandlungen des Deutschen Wissenschaftlichen Vereins zu Santiago, Chili, 1885–90. The Society possesses some 400 or 500 volumes of the Transactions of various Institutions, English, American, and Continental, together with a large number of pamphlets, which are virtually inaccessible to members, owing to their being unbound. These are now being temporarily bound in cloth covers and will be placed on the Library shelves for reference. Ninety-eight volumes are already finished, and the remainder will be proceeded with as quickly as possible.

Library Catalogue.—The first part of this useful publication, consisting of a general catalogue, was issued last year. It was hoped that the second part containing the Transactions of Societies, Journals, and Pamphlets would have been ready for issue before now. But the current clerical work of the Society has become so heavy that the Assistant Secretary was unable to attend to this. The Council having lately sanctioned the employment

of an office boy the Assistant Secretary will now be relieved of much of the merely mechanical work, thus giving him time for more important matters, including the completion of the Library Catalogue.

Meetings of Sections.—Only two sections were formed last year viz., a Medical and a Microscopical Section. The Medical Section held 7 meetings which were well attended. Besides important exhibits nine papers were read and discussed at those meetings. The Microscopical Section also held 7 meetings at which interesting exhibits were shown.

Civil Engineering Section.—In response to an application made to the Council in December last by Mr. J. A. MacDonald, M.I.C.E., M.I.M.E., &c., acting on behalf of those members of the Society who are Civil Engineers, it was resolved to form a Civil Engineering Section of the Society for the purpose of reading and discussing papers on both Civil and Mechanical Engineering. This has been carried into effect for this Session, the officers and committee having been elected at a provisional meeting held for that purpose last month, and I am very pleased to learn that there is every prospect of the new section becoming a most useful and successful one.

Only two other Sections were formed at the provisional meetings held last month viz., a Medical and a Microscopical Section, which in fact were already in existence from previous years.

Alteration in Bye-Laws: Increase in the number of members of the Council &c.—At the General Monthly Meeting held on May 7th last year certain amendments to Rule III. of our Bye-Laws were proposed, and agreed to at the following General Monthly Meeting held June 4th. The amended rules are to the effect that we elect now four Vice-Presidents instead of two, and ten other members of the Council (besides an Honorary Treasurer and one or more Hon. Secretaries) instead of six as previously. The elections this evening were made in accordance with these new rules. It is hoped that by thus increasing the number of our

Council marked benefits to the Society will be ensured. Another alteration in our Bye-Laws, made at the same time, provides for the office of President being tenable for two years in succession instead of one year only. It was felt that cases may arise where such a provision will be of absolute benefit to the Society and its working.

Conversazione.—On 10th December last the Society held a *Conversazione* in the Great Hall of the University which was, as usual, largely attended. In addition to numerous exhibits in Science and Art a special feature, which proved of great attraction to visitors, was the throwing open by the Professors of their Chemical, Physical, Engineering and Biological Laboratories. The new Chemical Laboratory replete with all modern appliances for teaching chemistry in all its branches, was open for the first time to public inspection. Experiments conducted in the different Laboratories by the Professors and their assistants were highly appreciated, and special thanks are due to these gentlemen.

The series of star photographs shown by Mr. Russell, B.A., C.M.G., F.R.S., were of great interest and much admired.

In Bacteriology Dr. Camac Wilkinson, a former pupil of Professor Koch in Berlin, attracted considerable attention by his exhibits of from 60 to 70 pure cultures in various media, chiefly gelatine-peptone glycerine, and agar-peptone. Pure growths of diphtheria bacillus, of bacillus of Glanders, and several cultures of Koch's comma bacillus of Asiatic cholera, also growths of bacillus of chicken cholera &c. &c. were shown by him.

The exhibits from the Departments of Agriculture, Public Instruction, Forests and Public Works were highly interesting.

Several members also contributed to the success of the *Conversazione* by valuable exhibits of Microscopes, Photographs, Works of Art, rare prints &c. A hearty acknowledgement is due to the various exhibitors for the most valuable assistance rendered by them in making this *Conversazione* not only interesting but highly instructive.

It is however a matter of regret, shared by many, that the exhibits are on view for a few hours only, during which time it is impossible to get more than a general glimpse of them. A few explanatory remarks given in connection with the more important exhibits would also largely increase the usefulness of these Conversaziones, thus bringing about a somewhat more satisfactory relationship between the trouble and expense involved and the practical results achieved.

Original Researches.—In continuation of the practice originated in 1881, to publish yearly a list of subjects, peculiar to Australia the investigation of which would be of great interest and value to the Colony, the Council invited original contributions and offered its medal together with a grant of £25 for the best original paper on the following subjects viz.:—

Series IX.—To be sent in not later than 1st May, 1890.

No. 31—The Influence of the Australian Climate (general and local) in the development and modification of Disease.

No. 32—On the Silver Ore Deposits of New South Wales.

No. 33—On the Occurrence of Precious Stones in New South Wales, with a description of the deposits in which they are found.

Four papers were received on the first subject (No. 31) but the Council did not consider any of them of sufficient merit to receive the award. No papers were received on the two other subjects (Nos. 32 and 33).

Series X.—Papers to be sent in not later than May 1st, 1891, comprises the following three subjects, viz. :—

No. 34—The Meteorology of Australia, New Zealand, and Tasmania. The Society's Medal and £25.

No. 35—Anatomy and Life History of the Echidna and Platypus. The Society's Medal and £25.

No. 36—The Microscopic Structure of Australian Rocks. The Society's Medal and £25.

Series XI.—To be sent in not later than 1st May, 1892.

No. 37—On the Iron Ore Deposits of New South Wales.
The Society's Medal and £25.

No. 38—On the Effect which Settlement in Australia has
produced upon Indigenous Vegetation ; especially
the depasturing of sheep and cattle. The Society's
Medal and £25.

No. 39—On the Coals and Coal Measures of Australasia.
The Society's Medal and £25.

Series XII.—To be sent in not later than 1st May, 1893.

No. 40—Upon the Weapons, Utensils, and Manufactures of
the Aborigines of Australia and Tasmania. The
Society's Medal and £25.

No. 41—On the effect of the Australian Climate upon the
Physical Development of the Australian-born
Population. The Society's Medal and £25.

No. 42—On the Injuries occasioned by Insect Pests upon
Introduced Trees. The Society's Medal and £25.

The competition is in no way confined to members of the Society nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being ; neither will an award be made for a mere compilation, however meritorious in its way. The communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor.

The Society is fully sensible that the money value of the prize will not repay an investigator for the expenditure of his time and labour, but it is hoped that the honour will be regarded as a sufficient inducement and reward. The successful papers will be published in the Society's annual volume. Fifty reprint copies will be furnished to the author free of expense.

Competitors are requested to write upon foolscap paper—on one side only. A motto must be used instead of the writer's name,

and each paper must be accompanied by a sealed envelope bearing the motto outside, and containing the writer's name and address inside. All communications to be addressed to the Honorary Secretaries.

Antarctic Exploration—As you are aware Professor Liversidge referred somewhat largely to this subject in his Presidential Address last year, from which it appears that a Committee of the British Association was formed in 1885, which presented three reports, while Baron von Müller of Melbourne, as early as 1886 strongly advocated an Antarctic Expedition. Nothing however, came of it; the request of the Agent General of Victoria made in 1887 to the Imperial Government for a subsidy of £5,000 towards the cost of such an Antarctic Expedition under the condition of Victoria giving a similar sum having been declined on two grounds, viz., that as regards the two objects then put forward in support of such an expedition, *i.e.*, promotion of trade and scientific enquiry, the first did not justify imperial contribution, and as to the second, that the proposed outlay of £10,000 on such an expedition could do but very little in the way of scientific investigation. At a meeting of the Australian Antarctic Exploration Committee held at Melbourne on 4th of March 1890, the munificent offer of Baron Oscar Dickson of Gothenburg, Sweden, to fit out and start a Swedish-Australian Expedition under the leadership of the celebrated Baron Nordenskjöld, to explore the Antarctic regions, provided Australia contribute half the estimated cost, viz., £5,000, while Baron Dickson offered to pay the other half, was brought before the members by the Consul for Sweden at Melbourne, Mr. Gundersen. This offer was enthusiastically received by the meeting, and the Victorian Branch of the Royal Geographical Society of Australasia in conjunction with the Royal Society of Victoria, at once set to work to enlist the hearty co-operation of the different Branches of the Royal Geographical Society of Australasia and other scientific societies in the Australian Colonies, with a view of getting the stipulated £5,000.

Notwithstanding however, that considerable efforts have been made to secure this comparatively small sum, the amount subscribed up to date is less than £1,000, and it is more than probable that the Swedish Australian Antarctic Expedition, which it was proposed to depart from Europe in a steamer specially fitted up for such purpose in July next, so as to start from Melbourne in the following September, and from Macquarie Island, the nearest depôt to polar land, in October—will for this season at least have to be given up, since only the four months of an Antarctic summer viz., October, - February, could be made use of for Antarctic Exploration.

The subject of Antarctic Exploration was also discussed by the Geographical Section at the Christchurch meeting of the Association for the Advancement of Science in January last, when a paper by Mr. G. S. Griffiths, F.R.G.S., President of the Section, on Australian and Antarctic Exploration was read and discussed. Baron Ferd. von Müller, as President of the Antarctic Exploration Committee of Victoria pointed out the impossibility of obtaining at the present time any large grant from either the Imperial or Colonial Governments and therefore advocated an expedition on lines of less magnitude and extending in the first place to only three or four months.

Admiral Ommanney in a letter to the *Times* strongly deprecates any idea of landing a party to pass the winter in the Antarctic regions. The exploration of these regions is acknowledged to be of the highest scientific interest and of considerable commercial value, especially to Australasia. The principal objects of such an expedition would be :—1. Further extension of geological knowledge in South-polar regions. 2. Scientific research including inquiry into the problems of physical geography, natural history, and meteorology. 3. Investigation of the fishery-industry—chiefly whale and seal.

With regard to Baron Dickson's offer I append here an extract reprinted from an article in the London *Times* of February 13th last :—"Baron Oscar Dickson, of Gothenburg, Sweden, who is

in London at present, naturally expresses some surprise at the conduct of the Australasian Geographical Society, which originally approached him with reference to the undertaking. The only condition which he required was that Australia should contribute £5,000, and he would do all else that was necessary. He estimates that for a suitable expedition, even on a comparatively small scale, something like £15,000 would be wanted. Two of the powerful Norwegian sealing vessels, specially constructed for ice navigation could be purchased for £7,000. A complete equipment of scientific instruments would probably cost £1,000; but Baron Dickson believes that such an equipment would be willingly supplied by the Swedish Government. At least one of the ships would have to be furnished with provisions and other supplies for two years, in case of accident: while the equipment of the second ship, the payment of crews, and other expenses would not leave a large balance out of the remaining £8,000. Baron Dickson would contribute £5,000, and would take upon himself the responsibility of obtaining the remainder. The bulk of it, he believes, he could obtain in Sweden and Norway, though he might give the Royal Geographical Society an opportunity of contributing, if it cared to do so. At all events if the Australians will find the moderate sum of £5,000, Baron Dickson is willing to be responsible for the balance. Although Baron Nordenskjöld had made up his mind to go on no more adventurous expeditions, yet his objections have been overcome, and he is willing to undertake the leadership of this expedition and take with him his son, who has proved himself of the right metal in a recent journey to Spitzbergen. With Baron Nordenskjöld as leader, success might almost be said to be secured. The plan was to send one ship as far south as possible, say to the neighbourhood of Mount Erebus. There the expedition would spend a whole year making regular observations, and carrying out explorations as far as practicable. The second ship would take up its station at the island of South Georgia, there to be ready for any emergency. Baron Dickson has thus made every

arrangement possible, so far as he is concerned, but there is no sign of the promised £5,000 from Australia."

I sincerely hope that the Governments of the different Colonies as well as private citizens may see fit to liberally contribute towards the cost of such a desirable undertaking as an Antarctic Exploration.

In order to bring this matter prominently before the public an interesting and well attended lecture on "The proposed Antarctic Expedition," illustrated by lime-light views, was given in the vestibule of the Sydney Town Hall under the auspices of the Royal Geographical Society of Australasia on Tuesday the 28th ultimo, by Dr. J. J. Wild, F.R.G.S., a member of the late Challenger Expedition. His Excellency the Governor and the Countess of Jersey were present.

In connection with geographical enterprise I must not omit to refer to the Expedition, which thanks to the patriotism and generosity of Sir Thomas Elder of Adelaide, (who is incurring the whole expense) has lately been organised by the Council of the South Australian Branch of the Royal Geographical Society of Australasia to explore the interior of this vast continent. The exploration party, comprising 14 members under the leadership of Mr. D. Lindsay have started a fortnight ago from Adelaide, and every lover of geographical research, and indeed every Australian must wish this expedition every possible success and a safe return.

Australian Association for the Advancement of Science.—This Association, which as you know held its first meeting in Sydney in 1888, and the next in Melbourne in 1890, assembled for its third meeting on the 15th of January last in Christchurch, New Zealand, under the Presidency of Sir James Hector, K.C.M.G., F.R.S. Professor Hutton, F.G.S., being Hon. Secretary. Several members of this Society were able to be present. The meeting was a very successful one in every way and was largely attended.

The following list gives the number of members on the roll for the three meetings held since 1888, viz. :—

	N.S.W.	Vict.	S.A.	W.A.	Q'land.	N. Terr.	Tasm.	N. Z.	Fiji.	Total.
1888. Sydney ...	560	130	59	3	46	1	18	50	—	857
1890. Melbourne...	323	580	73	2	33	—	30	37	1 *	1080
1891. Christchurch	243	185	57	—	26	—	22	235	2 †	776

* 1 From Canada.

† 6 From England.

Addresses were delivered on the opening day by the Governor of New Zealand, the Earl of Onslow, and by the President Sir James Hector. A large number of papers were read at the sectional meetings, the publication of which is looked forward to with great interest. The meetings lasted seven days. Excursions in the neighbourhood of Christchurch and for longer distances to places of interest were undertaken, the Committee appointed for the purpose having made the most complete arrangements to ensure the thorough success of the meeting and the enjoyment of the visitors. The reports of these annual meetings, of which two have now been published, form a valuable addition to the records of scientific work carried out in the Australasian Colonies, and entitles the association to the general support of all lovers of science, though only a comparatively small proportion of its members may be able to attend the meetings, except those who are living near.

The place of meeting for 1892 is fixed for Hobart, under the Presidency of the Governor of Tasmania, Sir R. Hamilton, K.C.M.G., who is also President of the Royal Society of Tasmania. From its central position and other advantages no doubt a large attendance may be anticipated.

Biological Station.—Ten years ago the late Professor Smith in his Presidential Address to this Society, made an energetic appeal for contributions towards the cost of establishing a Biological Laboratory at Watson's Bay, where the Government had given an eligible site, and also had promised to double the private subscriptions up to £300. The well known Russian naturalist, the late Baron Maclay, had for two or three years previously been endeavouring to establish a Zoological Station, and in a paper read

by him before the Linnean Society of N.S.W. in 1878 he warmly advocated such a step.

The practical interest of the Royal Societies of Victoria and New South Wales, together with several other scientific societies and private individuals, having been secured, a neat cottage was erected and fitted up for the purpose required. The contribution from this Society entitled us to nominate a worker, who would be received into the Laboratory with the right to use all its appliances free of charge, but no one applied for this privilege, and Baron Maclay remained its only occupant. In 1886 the Government resumed the site on which the station was erected for military purposes, giving £500 as compensation.

Professor Liversidge, who is a warm supporter of a Biological Station near Sydney and had been largely instrumental in procuring the late modest building in Watson's Bay, referred to this matter in his Presidential Addresses delivered to this Society in 1866 and last year. Since then the Government have granted the use of an excellent and convenient site at little Sirius Point, near Mossman's Bay, and it is proposed to erect a suitable building thereon as soon as sufficient funds are in hand. At present about £600 are available, but much more is required. Professor Haswell, Sc.D., issued in December last a circular letter, appealing for support and contributions. As this letter and some of the replies received by him fully explain the work in view, and also show the great interest taken therein by some of the most eminent naturalists of Europe, I republish the same here, with an earnest appeal to the members of this Society and all interested in the progress of scientific research in the department of Natural History, for which this Colony and Sydney especially, offers such a rich harvest. I may add that the Royal Society of London has lately granted £50 towards this object :

Biology Department, University of Sydney,

12th December, 1890.

Dear Sir,—It is intended to re-establish the Sydney Biological Station on new lines and in a more convenient position. The site of the former Station at Watson's Bay was resumed for military purposes in 1886—the

Government giving the sum of £500 as compensation for the loss of the building. This sum, with interest that has accrued, is all that the Trustees have at present at their disposal; and, in order to establish and equip the Station in a suitable manner, five or six times this amount will be required. The Government have intimated their willingness to assist by granting the use of a site suitable for the purpose. It is intended to construct one large Laboratory, with Aquaria and other necessary appliances, two or three smaller Laboratories, store-room and workshop, accommodation for a fisherman to act as boatman and caretaker, and, if possible, accommodation for a naturalist. With regard to this last, it is thought eminently desirable for the success of the undertaking that there should be attached to the Institution a resident naturalist continually engaged in researches on the fauna of the coast. The rest of the work done at the station would be carried out at their own expense by biologists from this or the other colonies, or visiting us from Europe. The results would be for the most part published in the local scientific societies' publications. The following gentlemen, the Trustees appointed by the Government, will be glad to receive contributions towards this national undertaking:—Hon. E. S. Combes, Dr. J. C. Cox, Prof. W. A. Haswell, Prof. Arch. Liversidge, Hon. James Norton, Dr. E. P. Ramsay.

I desire specially to direct your attention to the appended letters, referring to the proposed new Station, received by me from eminent biologists in Europe. Trusting to have your support and co-operation in this important undertaking, I am yours very truly,

WILLIAM A. HASWELL,

Professor of Biology, University of Sydney,
Hon. Secretary and Treasurer.

From Prof. E. Ray Lankester, F.R.S., of Oxford.

University Museum, Oxford, 27th October, 1890.

My dear Prof. Haswell,—When you were in England recently you spoke to me of a project for establishing a well-equipped marine laboratory on the shores of Port Jackson—similar to that at Naples, and to the one founded by me at Plymouth. I sincerely trust that this laboratory may come into existence, and that you may obtain funds for its erection and maintenance from the public authorities of the Colony as well as from philanthropic individuals. We were assisted here in starting the Plymouth Laboratory by a grant of £5,000 and £500 a year from the Government, by £2,000 from the Fishmongers' Company, and by grants from the Universities. Many private individuals gave each £100, and became nominal "Founders," while some, such as Mr. Robert Bayley have contributed as much as £1,000 to our funds. Valuable scientific work of all kinds has been done in our laboratory, although it is not three years since it was opened. I can assure you of the hearty interest of

men of science in this country in the projected laboratory at Sydney. Its harbour is known all the world over, not only for its beauty but for the extreme interest and richness of its marine life.

I am able to assure you of the interest taken in this matter by Lord and Lady Jersey, to whom I have mentioned your project, and I cannot but believe that, if the advantages to science and the importance to the fisheries secured by a marine laboratory are made clear to the leading men of New South Wales, they will establish one as a national institution worthy in its completeness and equipment to compare with the famous Australian Museum, and to give enviable distinction to the University of Sydney.

Believe me, yours faithfully,

E. RAY LANKESTER.

From Professor A. Giard, Paris.

Sorbonne, Faculté des Sciences.

Paris, 8 VII., 90.

Laboratoire de Zoologie Maritime de WIMEREUX, Pas-de-Calais.

Directeur: A. Giard.

Cher Professeur Haswell,—J'ai appris avec grand plaisir la nouvelle de la création d'une Station Biologique à Port Jackson, et je crois que tous les Zoologistes partageront ma satisfaction. Ce que nous savons déjà de la faune d'Australie (grâce surtout à vos nombreuses et brillantes découvertes) nous fait espérer des résultats bien intéressants quand vous posséderez une installation en rapport avec l'état actuel de la Science.

Il est impossible qu'une nation qui a marché si rapidement avec la voie de progrès n'accorde pas une assistance large et vigoureuse à des études dont les conséquences pratiques peuvent être et seront certainement très considérables.

Port Jackson me paraît une localité admirablement choisie pour servir de centre aux recherches de biologie maritime; mais les côtes d'Australie sont si étendues et si variées qu'il est bien désirable de voir ces recherches se poursuivre sur d'autres points du littoral.

Puissamment encouragée par une population intelligente et libérale, habilement dirigée par un travailleur infatigable, la Station Maritime de Port Jackson, deviendra bientôt, j'en suis convaincu, un laboratoire modèle comparable au bel établissement de Naples et en relations avec les laboratoires maritimes des tous les pays.

Aussi j'ai tenu à ce que la modeste Station de Wimereux fut des premières à vous féliciter de l'initiative que vous avez prise, et je vous envoie cher Professeur Haswell, l'assurance de ma vive sympathie.

A. GIARD.

From Prof. Dohrn, Director and Founder of the Naples Zoological Station.

Naples, 20th July, 1890.

Dear Dr. Haswell,—It is with great pleasure that I have heard of your plan to re-establish the Port Jackson Zoological Station scheme. You will certainly meet with the general approval of all leading Biologists, and if you could succeed to combine with any of the steamship companies for reduced prices of transport from Europe to Sydney, I am sure the Zoological Station in Sydney would soon become a centre for Biological Studies.

I would be glad if this, my opinion would have any influence upon your countrymen in New South Wales. And as I remember the past, when Miklouho-Maclay made his unfortunate attempts, I know that in the Government of your Colony there was a tendency to assist in this line of research; may this tendency help to the fulfilment of your plans, and may a public subscription be fruitful. Allow me to add to the subscription £5, and let me know where I best should send this small sum to.

Yours very sincerely,

Prof. ANTON DOHRN,

Director of the Zoological Station of Naples.

From Prof. W. C. MacIntosh, Professor of Natural History (Zoology) in the University of St. Andrew's.

St. Andrew's Marine Laboratory, 12th July, 1890.

My Dear Dr. Haswell,—I cannot too strongly urge upon you the advantage of founding a Zoological Station at Sydney in connection with the Biological teaching at the University; and I do so not upon mere abstract principles, but from practical experience of a Station in connection with the University here [*vide* enclosed printed paper.] We are peculiarly fortunate in having the sea in close proximity, and I understand you are similarly situated with an even richer sea at Sydney.

In the first place, it is only at such a Station that students can examine for themselves delicate marine things, can study their development, life histories, and minute structure. It is only there that frail specimens can be systematically procured for lecture-purposes, for practical classes, and for the carrying out of physiological investigations—especially those requiring continuous observation of living forms. It is there that students begin to appreciate the remarkable phases of life, for example, the so-called alteration of generations, phosphorescence in animals, the power of boring in timber, shells, rocks and other solid bodies, and the formation of tubes—often of beautiful structure—which harden in sea-water. The examination of the pelagic egg of a single fish will do more for their knowledge of development than a prolonged course of reading.

The views of life which are learned there are both appreciable and comprehensive, and both ordinary and Medical students readily take to the

study of living forms, and become deeply interested in their structure and physiology.

The great aim of an University being to encourage original research, as well as diffuse knowledge, such a Marine Station is indispensable in these times to both the Zoological and Botanical Departments. An University by the sea would fall short of performing its whole duty if it neglected so valuable an opportunity. While the importance of a Marine Station is thus so vital to the higher life of an University, it also touches very nearly the welfare and progress of other State Departments, *e.g.*, the Fisheries, and in certain respects the Naval service. I might say much more, but it is to be hoped that the foregoing brief statement will suffice to show the University authorities in Sydney, and also the Government, the importance of immediate action in the case.

W. MCINTOSH,

Professor of Natural History and
Convener of the Science Committee,
University of St. Andrew.

From Prof. J. Cossar Ewart, Professor of Natural History (Zoology) in the University of Edinburgh.

University, Edinburgh, August, 1890.

Dear Prof. Haswell,—I understand an attempt is being made to institute for the Australian Colonies a well-equipped Marine Station. As the University of Edinburgh is in many ways interested in the development of the Australasian Universities and Colleges, and as I am, from my connection with the Scottish Fishery Board, much interested in the scientific aspect of the fisheries, I trust you will allow me to express the wish that a large Laboratory on the lines of the one at Naples will ere long be established. With your rich and largely unexplored seas, you must have felt more keenly than we have that progress in Marine Biology is all but impossible without the use of Marine Laboratories.

We are no longer satisfied with a knowledge of the structure of lowly organisms. We especially want to know their development and life-history, and to understand the function of the various parts and organs of which they are composed. But in the case of marine plants and animals, it is impossible to attain this kind of knowledge unless we are in a position to study them under as nearly as possible natural conditions.

The Australian Colonies have already added largely to Zoological science, and if, as is anticipated, marine work is systematically carried on, valuable results will undoubtedly be gained, which, in addition to advancing science, may be the means of solving some of the many problems on which the development and regulation of the Fisheries so largely depend. Trusting that in the institution of the Marine Station you will have the

sympathy and assistance of all interested in Marine Biology, as well as those interested in the Fisheries, I am, yours very sincerely,

J. COSSAR EWART,

Professor of Natural History (Zoology),
University of Edinburgh.

Technical Education.—Having in the foregoing given a short report on the affairs in connection with our Society, I propose to refer briefly to the present position and progress of some branches of applied Science in New South Wales from which it will be seen that this Colony is making marked progress in the application of Science to the development of its natural resources and the improvement of the conditions under which we have to live. To bring this about the Government and Parliament have wisely recognised the great advantage, nay the necessity, of improving and extending in the first place the Department of Technical Education. In addition to the excellent opportunities given by our University for studying Science in all its branches, the Government, by the establishment of a Technical College and Technological Museum in Sydney, with branches in different parts of the Colony, have brought within the reach of every body who so desires it, the means of acquiring that scientific and technical knowledge which must in course of time be of immense advantage, not only to the fortunate possessor thereof, but to the Colony at large.

One of the buildings forming part of the new Technical College at Ultimo, was opened in March last. It comprises mechanical engineering workshops, in which among other subjects taught will be organised courses of electrical, mechanical, mining, and sanitary engineering. Branches of the Technical College have been established at Goulburn, Bathurst, West Maitland, Newcastle, and Broken Hill, and technical classes are held at several other country towns.

The Technological Museum in Sydney, which dates from the year 1880, when it was a branch of the Australian Museum, is now, together with the work of the former Board of Technical Education, taken over by the Minister for Public Instruction and

forms an integral part of that Department under the name of Technical Education Branch. Branch Museums are established in each of the towns where Branch Technical Colleges exist. With a view to acquire specimens for these local museums Mr. Maiden, F.L.S., F.C.S., the indefatigable Curator of the Sydney Technological Museum, has just published, through the Department of Public Instruction, a most useful pamphlet entitled: "Hints for the collection and preservation of raw products suitable for Technological Museums." In it Mr. Maiden gives a synopsis of desirable objects for such Museums, and appeals to every one desirous of helping in this important matter, to forward such specimens as may come under notice, to the local or central Technological Museums. The Railway Commissioners, recognising the importance of this work to the colony, have kindly granted free carriage by rail for specimens intended for such local or central Museums. Copies of this useful pamphlet may be obtained on application at the above mentioned Museums.

The Technological Museum in Sydney with its 30,000 specimens still located in an iron shed in the Domain, sadly requires improved accommodation. It is therefore a matter for congratulation that Parliament has already voted £19,000 (in addition to £5,000 for a site) for a Technological Museum worthy of the Colony. To give some idea of the extent to which the Colony is pushing Technical Education, it may be stated that contracts already let in connection with the Sydney College alone amount to close upon £48,000, while £20,000 are already voted by Parliament for Technical Colleges and Technological Museums at Bathurst, Broken Hill, Maitland and Newcastle.

Astronomy.—In astronomy the Sydney Observatory under the able management of Mr. H. C. Russell, B.A., C.M.G., F.R.S., Government Astronomer, has been adding materially to our knowledge of the southern skies by a series of photographs which take in all the most brilliant part of the Milky-Way, especially the parts in *Argo-novis*, *Crux*, and *Centaurus*. The photographs were taken with three hours and upwards of exposure, and the most perfect

apparatus and the quickest sensitive plates, and they reveal and record the existence of thousands of stars which have never before been recorded, and very many too faint to have been seen with any telescope, and likewise give the first photographic delineation of the remarkable nebula that surrounds the star *Eta Argus*; they show strange details in its convolutions which seem to prove beyond question, that it is a great spiral structure, and they confirm the discovery made by Mr. Russell twenty years since, that one of the most brilliant and remarkable parts of the nebula as seen by Herschel, has totally disappeared. In the great coal sack or dark space in *Cruce* these photographs reveal a multitude of stars, and in fact show that over nearly all of it, stars are about as numerous as in the neighbouring parts which look so bright to the unassisted eye; only one small space is devoid of stars, and at the same time they shew a number of dark spaces, lanes as it were in the Milky-Way, and other striking peculiarities never before suspected. The modern use of dry sensitive plates has put into the hands of astronomers a new means of research which makes it possible to advance in several directions entirely new, and in others to push discovery far beyond the point possible with the most powerful telescopes; heretofore it has been impossible to see large sections of the sky at one view and highly magnified, but the photograph does both and forms a permanent record of star groups amongst the countless multitudes of the Milky-Way that have never before been seen. In fact the photograph is equivalent to seeing the Milky-Way with new, or more correctly speaking, differently constituted eyes; the camera virtually sees the stars by the chemical energy of their light and the result is a survey of the stars from a new standpoint and brings with it many advantages.

Since the world's astronomers met in Paris to arrange for the grand photographic survey of the whole heavens, by which every star down to the fourteenth magnitude is to be brought from its hiding place and included in the permanent records of astronomy, just four years have elapsed, which have been spent in preparations

for this great work ; three years of the time were spent by the instrument makers, and every stage of the preparation for this great work has been marked by deliberation and the most careful criticism of every part. The work fairly bristles with difficulties, but at the meeting of the Conference in the first days of last month, the final resolutions will have been passed how the work shall be carried out, and in a few weeks, *i.e.*, as soon as these can be distributed to all the observatories, the great work will begin. It is a new departure, a grand step forward in the study of the stars and we wish it every success.

Agriculture.—One of the most important steps towards advancing the welfare and prosperity of this Country was taken when the Government decided last year to establish an Agricultural Department under the Minister for Mines and Agriculture. The object in view was twofold : Firstly to furnish the farmers with the best advice, based upon scientific investigations and practical experiments in all matters connected with their business, and secondly to establish an Agricultural College and Experimental Farm for the thorough education and training of young men desirous of becoming agriculturalists.

The appointment of Mr. H. C. L. Anderson, M.A., as Director of Agriculture, was soon followed by the engagement of a staff of scientists and experts, consisting of Dr. N. A. Cobb, as Pathologist, Mr. A. S. Olliff, F.E.S., as Entomologist, Dr. A. Helms as consulting Chemist, Mr. F. Turner, F.R.H.S., as consulting Botanist, and Mr. J. A. Despeissis, M.R.A.C., as Inspector of the wine-growing districts and expert in viticulture.

The thoroughly practical steps taken by the Department in order to advance Agriculture and assist the Agriculturalist in every possible way, were very soon in evidence on the publication of the first part of Vol. I., of the newly established *Agricultural Gazette of N.S.W.*, in July last, followed by parts ii. and iii. in August and December, and by parts i., ii., and iii. of Vol. II. in January, February and March last. It is the intention of the Department to issue monthly parts of this valuable Gazette in

future. Articles on insect pests, Australian rusts, manures, analyses of soils, vine growing and wine-making, description of the grasses of New South Wales, and on other subjects too numerous to mention here, form the contents of these useful publications, which have their value largely enhanced by the excellent illustrations accompanying the same.

The Agricultural College near Richmond, which was opened last month under the name of the Hawkesbury Agricultural College with Mr. J. L. Thompson as Principal, has already received more applications from young people wishing to enter as students than the present temporary buildings can accommodate, which shows unmistakably the appreciation of the public of the splendid opportunities thus offered by the Government to obtain for our young men a sound agricultural education, the results of which will no doubt be seen before many years in a great advance in agriculture—an industry of incalculable value to this Country.

The Forest Department of N.S.W.—The Department of Forests which formerly was a branch of the Mining Department, has during last year been re-formed as a separate Department under the Colonial Secretary, the services of Mr. J. Ednie Brown, F.L.S., as Director-General of Forests, (who successfully filled a similar position in South Australia) having been secured. The importance to the Colony of a well managed Forest Department will at once be apparent by the following few facts, with which I have been kindly supplied, and which, I am sure, will be highly satisfactory reading to every well-wisher of this colony:—The number of Forest Reserves is 944, and the area of reserves already proclaimed amounts to 5,579,000 acres, of which there are about four million acres covered with more or less good timber trees. Some 23,000 red cedar trees have already been planted. Great efforts are being made to encourage the natural regeneration of the red cedar forests, and already good results have been attained in this direction. Over 10,000 natural grown red cedar plants of various ages and sizes have been properly cleared round and otherwise attended to.

The red cedar forests are situated principally on the northern rivers, such as the Clarence, Richmond, Tweed, Bellenger and the Maclay. At the Gosford Nursery there is a stock this year of over 700,000 young plants, of which the principal are red cedars, *Pinus insignis*, *Pinus halepensis*, English oaks, poplars, olives, the most important of the Eucalypts of all the Colonies and the American Catalpa.

Some fifty men are now employed by the Department in thinning the natural red gum forests upon the Murray Flats. It is intended to plant experimental plantations this winter at Broken Hill and Wilcannia with the tree known as the Sugar Gum (*Eucalyptus corynocalyx*). The growing of timber for the mines is a matter of great importance. The sugar gum has been successfully established in several parts of South Australia in similar soil and situations to those mentioned. Strong efforts are being made to induce not only our cabinet makers, but those in Europe as well, to try our scrub timbers for the making of furniture. Amongst the timbers recommended are the following: red cedar, tulip-wood, rose-wood, bean, onion-wood, beech, ash, she-oak, black-wood, marble-wood, satin-wood, cork-wood, nut tree, rough fig, myall, beef-wood, myrtle, and yellow-wood.

For buildings and general construction work the following indigenous timbers are also being brought before the market:—iron-bark, mountain ash, red gum, blood-wood, stringy-bark, black-butt, tallow-wood, spotted gum, box, various kinds, and mahogany.

A Forest Bill is now in course of being drafted, under which the necessary powers will be given to the Department, whereby increased and more satisfactory results will accrue. The Department is now bringing out an illustrated book upon "The Forest Flora of New South Wales." The work of lithographing the plates is being done by the Government Printer, and it is expected that the first part will be published about the end of June next.

Botany.—In connection with the subject of agriculture and forestry, I may briefly refer to botany. During the past year

satisfactory progress has been made in the study of our flora, partly by the meritorious exertions of individuals and partly by the combined efforts of Societies. For more than forty years the eminent botanist of Victoria Baron Ferd. von Müller, K.C.M.G., M. and Ph.D., F.R.S., &c., has devoted his energies to the discovery and description of new plants, and the publication of works calculated to make known the resources of our vegetation. His systematic census of Australian plants is the crowning part of his labours. From it we find that the species of known Australian plants amount to-day to nearly 9,000, of which 3,251 species or over 36 per cent. of the Australian flora are indigenous in this Colony. Of botanical works, either published during last year, or in manuscript may be mentioned :—"The Flora of New South Wales," by Mr. Charles Moore, F.L.S., Director of the Botanical Gardens—a great desideratum for this Colony ready for publication. Mr. Moore has also directed attention to some new species of ferns and also to economic plants useful for their fibre. Mr. J. H. Maiden, F.L.S., F.C.S., Curator of the Technological Museum has published through the Department of Public Instruction, a most useful pamphlet on "Wattles and Wattle Barks," with a view to the cultivation of such species as may be of commercial value—a subject of deep interest to this Colony.

An important work by Baron Ferd. von Mueller, has lately been published in Victoria, under the title "Iconography of Australian Salsolaceous Plants." Treating as it does, on the Salt-bush plants of Australia, it is a subject not merely of scientific interest, but is of special importance to the pastoralist.

Mr. F. Turner, F.R.H.S., of the Agricultural Department has published in the *Agricultural Gazette of New South Wales* an interesting paper on Forage Plants and an elaborate Census of the Grasses of New South Wales, together with a popular description of each species. Other works of a botanical character in course of preparation I understand to be : (1) An additional number of Mr. R. D. Fitzgerald's *Australian Orchids*, in which he describes and figures a genus new to science. (2) The first number of "The

Forest Flora of New South Wales," by Mr. J. Ednie Brown, F.L.S., Director-General of Forests in New South Wales. (3) A second edition, with additions, of "Plants indigenous in the neighbourhood of Sydney," by the Rev. Dr. Woolls, F.L.S.

The Linnean Society of New South Wales deserves special mention here for its great services in fostering a spirit of scientific inquiry, not only in Botany but in Natural History generally. The name of the Hon. Sir William Macleay, M.L.C., F.L.S., should not be omitted when speaking of the Linnean Society of New South Wales; very much of its success is due to the great interest taken by him in the Natural Sciences and to his princely munificence by which the Linnean Society has obtained a fine hall, enriched with many scientific books and recently endowed by him with no less than £14,000. Sir William has moreover shown his public spirit and his great interest in the fostering of the study of Natural History by the donation to the Sydney University of what is now known as the Macleay Museum.

I should also not omit to refer approvingly to the Field Naturalists' Society of New South Wales, which held its first annual meeting and exhibition on the 1st and 2nd April last, under the Presidency of Mr. J. H. Maiden, F.L.S., F.C.S., when a very encouraging report was presented. The periodical excursions in search of specimens may induce many young persons to pursue the paths of science. A similar Society in Victoria has effected much good in this direction.

The Agricultural and Forest Departments, though principally directed to practical matters, will no doubt exercise a powerful influence on the botany of this colony and lead to the accurate study of those species which are of economic value.

Water Conservation and Irrigation.—The importance to this Colony of a well considered scheme of Water Conservation and Irrigation does not here require to be insisted on, being universally admitted. It is therefore a matter of congratulation that the Government saw fit to establish last year a special Branch of the

Mining and Irrigation Department, under the name of Water Conservation and Irrigation Branch, the chief officer of which is Mr. H. G. McKinney, M.E., Roy. Univ. Irel., M.I.C.E. I am indebted to him for the information I am able to give you on this subject in the following, and feel sure that it will be of general interest.

Until recent years it was assumed, even by advocates of irrigation, that the rainfall in the Coast District was sufficient for the requirements of agriculture and horticulture, or at all events so nearly sufficient that any outlay on work for irrigation would not be warranted. That a remarkable change has taken place in public opinion is evident when we consider that there are now many irrigated orchards in the Coast District, that the Mulgoa Irrigation Act authorising irrigation from the Nepean River has been passed, and that at least one other private Bill dealing with irrigation from the coastal rivers has been announced. If then irrigation is found necessary near the coast, how much more is it necessary in the western plains where the rainfall varies generally from one-half to one-third of that in the coastal district? The area of that part of the colony west of the summit of the Dividing Range may be taken at 255,000 square miles, and it is this area which has first to be considered in connection with works for water conservation and irrigation. The mountainous and hilly country between the summit of the Dividing Range and the great alluvial plains may be taken at about 76,000 square miles, and the area of the north-western portion of the colony beyond the catchment of the River Darling at 21,000 square miles. The net area of alluvial plains and undulating country within the influence of the western river system thus amounts to about 158,000 square miles. It is scarcely necessary to state that under the most favourable circumstances a very small proportion of this area can be irrigated; but only those acquainted with the western plains can appreciate the important effect which irrigated areas, amounting in the aggregate to even the five-hundredth part of the irrigable land, would have on the general prosperity of the country.

In order to be in a position to deal with the great question of utilizing the rivers, special legislation is required to define the rights of the State and of individuals to water and to settle the important question of riparian rights. A Bill with these objects in view was read last Session, and leave for its introduction was given to the Minister for Mines and Agriculture, but there was no opportunity to proceed further with the matter.

Action is being taken by the Water Conservation and Irrigation Branch of the Department of Mines and Agriculture, including the prosecution of surveys throughout the districts most favourably situated for the conservation of water and for irrigation. The districts dealt with include the alluvial plains of the Murray, Murrumbidgee, Lachlan, Macquarie, Namoi, and Darling, and the length of lines surveyed and levelled up till the end of January amount to about 5,400 miles. These surveys, which are still in progress, have shown the practicability of canals from the Murray and Murrumbidgee, and they have also shown that the natural outflows from the Lachlan and the Macquarie can be improved and utilised to great advantage with a moderate outlay. The project for filling Lake Urana has also been shown to be a much easier work than was at first anticipated. In the case of the River Murray it is proposed to construct a canal capable of carrying two thousand cubic feet per second, and this canal it is found can have its full supply from the river during six months in every year, on an average. If even one-third of this quantity were wasted or lost by percolation, absorption, and evaporation in the distributing channels, the area of land which could be flooded to a depth of three inches every twenty-four hours would amount to over ten thousand acres. The supply of water to feed this canal is most abundant in the Spring and early Summer months when it is most generally required.

The Murrumbidgee is not so regular in its flow as the Murray, but even in this case it is found that a full supply can be obtained for an average period of three months in every year, and that a fair supply can be obtained during five other months. It is

proposed to make provision to fill Lake Urana every year while the Murrumbidgee is in flood, and a branch canal capable of filling the Lake in three months is included in the project. Lake Urana when filled will contain a supply of water seventeen thousand acres in extent, and with an average depth of about sixteen feet.

The other western rivers are much more uncertain in their flow, and their conditions will require a different class of work. The numerous effluent channels from the Darling, the Lachlan, and the Macquarie, afford ready means of distributing the surplus waters of these rivers, while in the cases of the first two there are lakes and other natural depressions which can be converted into storage reservoirs. The works which have been carried out in Victoria in connection with the Wimmera River, which is smaller than and quite as uncertain as the Macquarie, show how much can be done under such circumstances to provide permanent water to a whole district. They also show that by the construction of a system of weirs, which hold up a constant supply in the river channel, the loss by percolation and absorption is greatly diminished, and the available supply proportionately increased.

The Water Conservation and Irrigation Branch only came into existence last year, so that even if there had been proper legislation in force, there has not been sufficient time to prepare the designs for any large schemes. The most important work under construction is a weir in the River Lachlan to divert a supply of flood water into the Willandra Billabong. This billabong, or creek, which carries off a portion of the waters of the Lachlan during high flood, has been traced to within about forty miles of the River Darling where it turns southward towards the Murray. Under existing circumstances, only the highest floods affect the Willandra Billabong, but after the river is complete, a portion of every moderate flood will be diverted. The construction of this work will directly affect the value of over eighty thousand acres of Crown land, and its importance to existing holdings may be imagined from the fact that one pastoralist alone offered to guarantee interest on the

cost of the work if necessary. The question of the storage of water before it reaches the plains has not been lost sight of. Up to the present time, four sites have been found which can be recommended. The difficulty is to find sites at which the quantity of water stored would be sufficient to justify the outlay.

During the past two years the seasons have been remarkably favourable, and it is doubtful whether some of the western rivers ever remained high for such long periods. An old resident on the River Lachlan, who keeps up a careful record, states that he believes that at only one previous period since the European settlement of the country had the Lachlan remained high for such a long period. In the northern part of the colony the water conservation surveys had to be suspended for months on account of the floods. This state of affairs cannot be expected to last and to prepare for the next drought, the most important steps required are—first, the passing of a Water Conservation Bill; and secondly, the prosecution of work in the districts most affected by want of water.

Mineral and Medicinal Waters.—Under this head, Professor Liversidge, in his Presidential Address last year, referred to the desirability of a thorough investigation of the mineral waters of the Colony and Australia generally.

That we possess many mineral waters in these Colonies, which may be of considerable medicinal value, there is no doubt, and if the same were found in Europe they would long ago, not only have been generally known but largely developed, and practically made use of. Mr. Ludwig Bruck, of Sydney, published in January last in the *Australian Medical Gazette*, a paper on the Mineral Springs of Australia, since reprinted in pamphlet form. Therein the mineral waters with their analyses and therapeutic properties are given. The best known ones are all in Victoria, while the only partly developed mineral spring in this Colony is stated to be the Rock Flat natural soda spring in the Manaro District, ten miles from Cooma.

Other Mineral Springs in New South Wales are given, viz—Ballingore, about eighteen miles from Dubbo, containing chiefly bicarbonates of soda, potash, lime and magnesia. Broken Hill with several weak alkaline sulphated waters charged with sodium- and magnesium-sulphate.

Mineral Waters found near Nyngan, Rylestone, Wilcannia, Cuttaburra, and Mittagong, are briefly described, which shows sufficiently that a more systematic developement of our mineral and medicinal waters would soon become of great advantage to the Colony at large, and of great benefit to many patients who cannot afford to resort to a voyage to some European spa in search of health.

Recent Work of the Geological Survey of N.S.W.—An examination of the Clarence coal basin by Mr. C. S. Wilkinson, F.G.S., has led to the important discovery of the existence of the Hawkesbury Sandstone in that area, occupying an intermediate position in the basin, which may be now divided thus:—(a) Upper Clarence Series, Wianamatta Shales; (b) Middle Clarence Series, or Hawkesbury Sandstone; (c) Lower Clarence Series, Narrabeen Shales of the Sydney area. Coal seams are developed in the Clarence Series proper, but have not been, so far, profitably worked.

Further examination of the Permo-Carboniferous Coal-measures in the Newcastle area by Mr. T. W. Edgeworth David, B.A., has resulted in the discovery of volcanic rocks, 1500 feet thick, interbedded with the marine strata, which may be the equivalent of the volcanic series of Kiama, and perhaps homotaxial with those of the Bowen River Coal-field in Queensland, and may therefore have considerable classificatory value as regards the co-relation of the East Australian Palæozoic Coal-fields.

A sketch survey by Mr. William Anderson, of a portion of the western plains between Byrock and Nevertire, has proved that the Lower Cretaceous rocks, in which supplies of artesian water are likely to be obtained, have a very much greater extension in a southerly direction than was originally supposed, as

they have now been traced at least as far south as the latter locality.

A detailed examination of the principal iron deposits by Messrs. C. S. Wilkinson and T. W. Edgeworth David show that they are centered respectively (1) in the Mittagong and Picton Districts, and (2) in localities contiguous to the so-called Western Coal-fields. The total quantity of iron-ore at present known as available in New South Wales is estimated by Mr. C. S. Wilkinson at about twelve million tons.

Under the superintendence of Mr. C. S. Wilkinson, assisted by Mr. J. E. Carne, the display of New South Wales minerals at the Mining Exhibition recently held at the Crystal Palace, London, was rendered complete and instructive and entirely worthy of the country represented.

Connected with Palæontological work the following memoirs were issued under the editorship of Mr. R. Etheridge, Junr. :— (1) Palæozoic and Mesozoic Coal Plants of Eastern Australia and Tasmania, by the late Dr. O. Feismantel. (2) Fossil Fishes of the Hawkesbury Series at Gosford, by Mr. A. S. Woodward, F.L.S., F.G.S., of the British Museum. (3) Mesozoic and Tertiary Insects of New South Wales, by Messrs. R. Etheridge, Junr., and A. S. Olliff, F.E.S.

In addition to the above, three parts of the Records of the Geological Survey of New South Wales were published, containing numerous papers of scientific interest.

Mr. R. Etheridge, Junr., also published Part I. of a Catalogue of Works relating to the Aborigines of Australia and Tasmania, which will be of great service to the student of Australian Anthropology.

Mining and Metallurgy.—Shortly we shall be in possession of the annual report of the Department of Mines for 1890 which will, like its predecessors, treat exhaustively of the progress and production of our mining industry. By the courtesy of the Honorable the Secretary for Mines and Agriculture I am enabled

to give in the following a comparative statement of the chief mineral productions of this colony in 1889 and 1890. They are as under :—

Description of Mineral.	Quantity produced in		Estimated Value in	
	1889.	1890.	1889.	1890.
	Ozs.	Ozs.	£	£
Gold	119,759	127,760	434,070	460,284
Silver Bullion	416,895	496,552	72,001	95,410
	Tons.	Tons.		
Silver Lead and Silver Lead Ore	81,545	131,038	1,899,197	2,667,144
Antimony and Antimony Ore	221	1,026	3,344	20,240
Copper and Copper Regulus	4,182	3,745	206,641	173,311
Tin and Tin Ore	4,650	3,668	415,171	329,841
Coal	3,655,632	3,060,876	1,632,848	1,279,088
Coke ... ..	...	31,097	...	41,147
Shale	40,561	56,010	77,666	104,103
Limestone Flux ... ..	...	41,436	...	41,989
Alum ... ..	...	220	...	3,000
Manganese ... ..	...	100	...	325
		lbs.		
Opals ... ..	...	195	...	15,600

The value of the above enumerated metals and minerals, produced in New South Wales in 1890, amounts to no less than £5,231,482, an increase of nearly half a million sterling over 1889. A comparison of the returns for 1890 with the previous year, shows an increase of 8000 ounces in Gold; while the produce of Silver Bullion, Silver Lead Bullion and Silver Lead Ore amounted together to no less than £2,762,554, being nearly £800,000 more than the output of 1889, and nearly $2\frac{1}{2}$ times as much as that of 1888. The increase has been most remarkable, and shows the wonderful development of this industry during the last few years, fully confirming the anticipation of Mr. C. S. Wilkinson, Government Geologist, as foreshadowed in his Report to the Minister for Mines in 1884. As is well known, the Broken Hill Proprietary Company is the chief producer. From May, 1886, to 30th November, 1890, this Company has produced out of 483,078 tons of ore treated, 84,127 tons of Silver Lead Bullion, containing 20,594,272 ounces of fine Silver and 83,413 tons of Lead. The production of Antimony and Antimony Ore has also increased during last year by about £17,000 in value.

A special feature in last year's production is to be noticed in the last item of the above list, viz—195lbs. Opals, valued at £15,600 ; they were found at Whitecliffs, Momba Station, about 57 miles from Wilcannia. The principal reductions in last year's output are 1,000 tons less of Tin and Tin-ore to the value of about £85,000, and of Coal a diminished production of no less than about 600,000 tons of a value of about £353,000. Deducting therefrom £41,147 as the value of Coke produced in 1890, we have a nett deficiency in the value of Coal produced in 1890, as compared with 1889, of about £312,000—the direct result of last year's lamentable strike.

The amount of New South Wales Gold received at the Mint in 1890 was 119,564 ounces, against an average of 110,650 ounces during the previous ten years. The Gold from this Colony, however, was only 14·86 per cent. of the total amount received by the Mint in 1890 (804,123 ounces), while Queensland contributed 619,367 ounces, or, a little over 77 per cent., of which Mount Morgan furnished 227,053 ounces, Charters Towers and other Queensland Goldfields 392,314 ounces.

No Iron was produced during last year from colonial ores. A great impetus to the Colonial Iron Industry will, no doubt, be given by the fact that the Government have invited tenders (to be received up to 24th June next) for the supply of 175,000 tons of steel rails, to be entirely manufactured in this Colony out of colonial ores ; fluxes, fuel, and other materials required for their production to be also raised in this colony. From a Report of Mr. C. S. Wilkinson, F.G.S., the Government Geologist, to the Minister of Mines, dated 30th January last, it would appear that the quantity of Iron-ore available in this Colony, so far as can at present be ascertained, amounts to 12,944,000 tons, estimated to contain 5,853,180 tons of metallic Iron. This quantity, calculated upon the present imports of Iron and Iron manufactures, would be sufficient to supply the demands of this colony for a period of thirty-five years.

Among the branches of technical science, I do not think any one more important to this colony than that of Mining and Metallurgy, and it is in the latter that much will have yet to be done to reap the full benefits of the vast resources of mineral wealth in which New South Wales abounds. Some of our ores are so complex and refractory that only very skilled treatment will give satisfactory results. The want of the necessary scientific and practical education on the part of many of those, under whose direction certain mining properties have been placed, has hitherto in many instances been the cause of utter failure and disappointment. The Mining Department by the judicious application of the Prospecting Vote is doing good work by encouraging the discovery of new metalliferous lodes, while the Laboratory attached to the Mining Department, is kept fully at work in determining the value, or otherwise, of mineral samples submitted for examination from all parts of the colony. Last year several thousands of samples of ores were thus examined by Mr. J. C. H. Mingaye, F.C.S., the Government Assayer and his Assistants. It is evident, however, that the finding of a metalliferous lode, or the assaying of small samples of ore is only one step towards the development of a mine, and as regards the assaying of *small* samples of ores, it cannot be pointed out too strongly and frequently that the results of such assays are more often misleading than of real practical value. Another mistake generally made is this, that small samples are desired to be assayed merely for such metals as are expected to be present, viz—gold, silver, lead, &c., while a more complete analysis of a bulk sample, taken from about one or two tons of ore, would often reveal the presence of substances, which greatly interfere with the proper extraction of the desired metals, and would therefore necessitate the adoption of special processes for the successful treatment of the ore on a large scale.

If the Government, as I understand, are desirous of still further assisting the development of our mineral resources, I would recommend the establishment of works where ores in bulk, say

from one to three tons, could be crushed, thoroughly sampled, and analysed. Such an analysis would enable a properly qualified metallurgist to devise means for their necessary treatment.

Establishments such as exist in Freiberg and Claussthal in Saxony, which combine complete mining schools with metallurgical works, where all kinds of ore are commercially treated, may probably—for the present at least—be on too large a scale for this country. These places are conveniently situated to the greatest centres of art and manufacture in the old world, and can thus adopt processes to utilize bye-products, and find a ready market for them. Besides we have yet to learn more thoroughly, in a practical and precise way, what minerals we have in quantity and how we can make the most of them under existing circumstances. The trouble hitherto has been to arrive at the truth of what the working bulk of a mine really is. With that known, private enterprise could then step in and undertake on its own behalf a search for the proper treatment.

The small quartz-crushing and amalgamating machinery in use in the Sydney Mint for the last twenty-five years for the treatment of auriferous quartz in lots up to two or three tons for the public, has done some good service in times past, but is not adapted for treating any auriferous ores containing pyrites, etc., since no appliances for roasting, or for any other treatment than crushing and amalgamating are available. The time has arrived for relieving the Mint of this sort of work and for the erection, in connection with the Mines Department, of a modern plant for the treatment of auriferous ores in bulk samples. I am no advocate of looking for everything to the helping hand of the Government at the serious risk of crushing or unduly interfering with private enterprise.

Judging from the number of metallurgical patents taken out in this colony within the last four years, the treatment of metalliferous ores has received considerable attention. The following list gives the number of metallurgical patents granted in New South Wales :—

			<i>For Machinery.</i>		<i>For Processes.</i>	
In 1887	...	...	9	...	...	7
1888	...	...	19	...	...	17
1889	...	...	29	...	...	23
1890	...	...	30	...	...	22

Unfortunately for some of the patentees, as well as the public, many patents are found unsuitable for practical and profitable working on a large scale, though feasible in theory, and thus it is that we hear so little about them.

I may be pardoned if I point out a few of the prizes for inventions of commercially workable methods—there is yet the “Gold in pyrites” problem. Chlorination has in its details advanced considerably and the working been cheapened, yet our local conditions in many parts are such, that chlorination is too expensive. A good method by which Gold can be effectively extracted from raw or unroasted pyrites would seem to be the method of the future. Our Antimony ores are now an important item of export, yet it is only a portion of the ore which is raised that finds a market in Europe. The man and the method to utilize the heaps of low grade ores is wanted. Gold in payable quantities is often associated with the Antimony, so that in solving the problem of treating low grade Antimony ores, both the saving of the Gold and the Antimony has to be taken into consideration.

The Silver and Lead production of this Colony, important as it is, will yet attain to greater dimensions. Here, too, is ample scope for inventiveness. A few months ago a notice appeared in our newspapers stating that “in view of the millions of tons of Galena ore now in sight in the mines at Broken Hill, special attention is being given to the matter of treating.” It may not be generally known that the sulphide ores of the Barrier mines carry, in addition to their silver and lead contents, considerable percentages of Zinc, sufficient indeed that, could a workable method of extracting and saving it be got, Australia would become one of the World’s great Zinc-producers. To-day not a ton of Zinc is saved from those ores carrying it in important

quantities, and we see the strange spectacle of mines with Zinciferous Lead ores working methods by which attention is directed to extracting Lead, worth £12 to £13 per ton, and letting Zinc worth £21 to £23 per ton go to waste. I may probably be told it is not worth while to save it while profits can be made without doing so, that it is an annoyance and a trouble; and thus Zinc, one of the chief sinners in the so-called "refractory ores," has always been looked upon as an enemy. May it not be worth while to make a friend of it?

Before concluding, I would like to refer briefly to the need of a well-arranged and well-displayed Mining, Geological, and Metallurgical Museum. The Museum attached to the Mining Department can only be regarded as a make-shift, being ill-housed, and from want of space the efforts in this direction of the Staff of the Geological Branch are paralyzed. Magnificent collections are frequently sent abroad for exhibition purposes, from whence they seldom or never come back, while the collections in Sydney are suffering from want of an appropriate building. What is needed is a new building, and an annual sum for the support of a first-class Mining Museum.

I fear I have exhausted your patience, and must therefore leave untouched other matters which I had intended to embody in this Address. It is with sincere thanks to the members of our Society, and especially to the Council, for their kindness and support during the past year while I had the honour of occupying the chair, that I now vacate the same in favour of Mr. H. C. Russell, B.A., C.M.G., F.R.S., who indeed requires no introduction from me. He is well known to you all as one of our most valued members. May the Society, under his able Presidency, prosper in every way, and fully justify the liberal support granted to it by Government and Parliament.

NOTES ON THE LARGE DEATH RATE AMONG
AUSTRALIAN SHEEP, IN COUNTRY INFECTED WITH
CUMBERLAND DISEASE, OR SPLENIC FEVER.

By M. ADRIEN LOIR.

[*Read before the Royal Society of N.S. Wales, June 3, 1891.*]

I DESIRE to direct the attention of the Royal Society to the great percentage of deaths which result from this disease in the infected portions of the Colony. What is the total amount of losses occasioned by Cumberland Disease no one can estimate. Even at the present time deaths caused by the malady are imputed to poisonous plants. The figures generally accepted as correct are 200,000 sheep a year, and as the disease only affects a comparatively restricted area of the Colony, this proportion is sufficiently alarming, but is nothing as compared with the reality. Pastoralists, for reasons easy to understand, do not like to admit the losses they sustain, yet it is not necessary to have been brought much into contact with them in order to become aware that the mortality ranges as high as 25%, 30%, and 35% in certain parts of the country. This proportion is enormous when it is remembered that in Europe a death rate of 10% to 12% is looked upon as very considerable; here however, a percentage of 30% is not uncommon. Squatters frequently remark, "My birth-rate does not make up for my losses by Cumberland Disease." I asked one of them the reason, and this was his reply:—"Referring to the mortality from the Anthrax Disease upon a property with which I was connected, I have to advise you that the loss amounted one year with another to between 30% and 35%, and as a matter of fact the increase from the breeding flock of half the total number kept did not compensate for the loss from this cause." Another squatter informed me that the death rate in badly infected country is from 37% to 40%.

Why should this great mortality take place and is there no means by which it could be prevented? I will not refer to vaccination which is certainly the best means to reduce the mortality to a minimum, but will allude to some other methods which may tend to this end.

Australian Cumberland Disease is no more virulent than its European prototype, and animals are no more susceptible in Australia to the effects of the virus of the disease than they are in Europe. I have ascertained this by inoculating guinea-pigs and rabbits with the virus and find that they succumbed to its effects after the same lapse of time as they do in Europe. Moreover as is the case in France, all cattle do not die after a virulent inoculation. At the Junee demonstration nineteen sheep inoculated with blood taken from an animal which had died from Cumberland Disease succumbed in from thirty to sixty-three hours after inoculation, the average period of incubation being practically the same as was the case with twenty sheep which died in France as a result of a similar experiment made by M. Pasteur himself upon animals under conditions identically the same.

But although in Australia the microbe is not more virulent than in Europe, there are nevertheless cases in which death ensues very rapidly. It is said that, more especially among travelling sheep, periods of incubation lasting only eighteen to twenty hours have been known. At the time of the experiments made at Junee, the following were undertaken in order to see whether exhaustion resulting from over-driving could account for such a short period of incubation.

Four sheep were inoculated at 2 p.m., on the 5th October, with blood taken from the heart of a sheep which had died of Anthrax. The sheep were then kept moving for six or seven hours in the paddock, as if they were being driven on the road. In this way their temperature was raised considerably over what it would have been if the sheep had been left quietly in the paddock; and they suffered in some degree from exhaustion, but not to anything

like the same extent as if they had been long on the road, and had been weakened from want of grass and water and over-driving.

On the following day (6th October), at 2 p.m., one of the inoculated sheep died ; at 4 p.m. another of these sheep died ; at 6.30 a.m. of the 7th October, another inoculated sheep died ; and at 7.30 a.m. of that date the fourth and last inoculated sheep died. From this it will be seen that the two first deaths occurred within a shorter time than those of any of the other sheep which died of inoculation with virulent virus during the demonstration, and that the average period of inoculation of the whole four sheep—thirty-three hours—is considerably less than that of the other inoculated sheep ; and the result, indicates that the supposition may be taken as correct, that conditions favourable to a speedy development and termination of the disease being given—such as fever, starvation, and exhaustion—surprise need not be occasioned if deaths occur among travelling sheep within twenty hours of their coming on infected ground.

Some months back M. Charrin of the Institute Pasteur in Paris, investigated the action produced by fatigue on the evolution of Cumberland Disease. The animals experimented upon were white rats, which are not very susceptible to the virus. A number of rats having been inoculated with Cumberland Disease, some of them were allowed to remain in repose while the others were subjected to an “over-driving” process consisting of placing them in a cylinder one metre in diameter, and similar to those sometimes placed in squirrel’s cages. The cylinder turned on its axis ten times a minute, and the animals which were shut up in it were compelled to walk in a direction opposite to that of the motion applied to the cylinder, and they walked thus a distance of 2,260 metres an hour. The fatigue imposed upon these inoculated animals produced an effect favourable to the infection, and the exhausted animals always died before those which were allowed to remain in a state of repose.

It is therefore conclusive that in the case of Cumberland Disease, as in many other diseases, exhaustion favours the develop-

ment of the infection, and it is also certain that the conditions under which sheep are kept in Australia are very favourable to "exhaustion." In the immense paddocks where they are left to their own devices in flocks of 10,000 or 20,000, and where the noise caused by the falling of a tree is sufficient to send them panic-stricken from one end of the enclosure to the other, they are certainly more liable to exhaustion than in the small fields common to European agriculture, where they are limited in numbers and nearly always watched.

There is another reason which may be looked upon as explaining in some degree the great mortality in Australia. Here the dangerous season is much longer than in Europe, so that the animals have to struggle against the infection during a far more extended period than in France, for example, and the chances of infection are thus greatly increased.

A third reason, and the one which could perhaps be easily avoided by the squatter if its importance was well understood, is the neglect which exists in the manner of disposing of the bodies of animals which have died from the disease. In France when an animal succumbs there is nearly always some person who takes away the body and carries it to an establishment where he gets paid for his trouble, and where the sheep is converted into tallow. In places situated at a distance from such manufactories there are veritable cemeteries for sheep, which are inclosed with fences in order that other animals may not be depastured thereon. Here, unfortunately, when an animal dies, it remains on the same spot and is torn to pieces by birds of prey and dingoes, and thus the contagion is spread. This has moreover been going on for many years past, so that it can be said that the soil is in some places literally saturated with microbes, and the danger of contagion is thus immensely increased.

It is not possible to compel the squatters to burn the bodies. Many fear, and with some show of reason, that by doing so they might start bush-fires; but if they properly understood how dangerous it is to other stock that dead animals should be left

about, they would doubtless devise some simple expedient for burning the remains, without incurring the risk of bush-fires. It is certain that as soon as vaccination becomes generally adopted the number of cases of Cumberland Disease will diminish year by year, as is the case in those European countries in which it has become customary. By burning the bodies, the actual causes of contagion of Cumberland Disease, for animals and of malignant pustules in man would be diminished, and this remark applies not only to Cumberland Disease, but to all contagious diseases of stock in general.

At the present time, moreover, it is not only of the gravest importance to arrest the effects of contagious diseases in stock in order that the number of flocks and herds and the pastoral wealth of the country may be increased, but more especially, in view of the great impetus recently given to the meat-export trade. Is it not, therefore, to the best interests of the Colonies to adopt every possible precaution to prevent European Bacteriologists from finding in Australian meat, microbes or remains of microbes in large quantities, a discovery to which the utmost publicity would be given by those interested in stopping the importation of foreign meat? To avoid this every effort must be made, in addition to the existing law prohibiting the use of the flesh of diseased animals for food, to reduce the number of cases of disease in stock from year to year, and it would be well if every Australian stock-owner would bear in mind that the importation of hog's flesh from America has been interdicted in Europe for many years past.

DISCUSSION.

Mr. MOORE—Speaking from an experience of thirty-five years, and again more recently, the first case was noticed at Fullagar's, on the Parramatta Road, in a saddle-back paddock, on one side of which the animals died and on the other none. In conjunction with a botanist the plants were noticed, and identified. Having read Pasteur's investigations the cause was now quite clear. Again at Cassillis (Busby's Station) the sheep were dying

day by day ; on the other side of the dry creek (Denison's Station) no sheep died. The plants were again noticed and a report to Government made. The bodies were buried and not burned. On the Liverpool Plains some stations were deserted for a season and after four years sheep returned and were healthy. Mr. Moore quite agreed with M. Loir with respect to burning.

Professor ANDERSON STUART—Australian graziers are greatly indebted to M. Loir for bringing the matter before the Australian public. M. Challin's paper may be in Sydney but not translated. If M. Loir's paper is published *in extenso* it should be spread over the length and breadth of Australia. Mr. Moore's supposition of the duration of life of microbes was correct. Koch proved that Anthrax bacillus could survive three weeks in moist soil and the spores longer, but not into many years. M. Loir has thrown out excellent suggestions regarding bacteriologists finding bacteria in meat exported. There are always persons who would delight to find microbes, and English Agricultural papers would use the fact with advantage and ring the death-knell of Australian meat in England for some time to come.

The Hon. H. N. MACLAURIN, M.D.—Listened with pleasure and rose to speak to the remark made by Prof. Stuart *re* risk of microbes being found in exported meat. The existing law renders it a criminal offence to sell for food animals dying from Anthrax or Enlarged Spleen, whilst persons selling meat affected with bacillus of Tubercle are open to a fine of £10, and only very foolish and very wicked persons would do so.

Prof. ANDERSON STUART—Was aware of such a law, but there are persons who would not think it very wicked to freeze up a carcase dying from disease. In proof of which he related a Scotch experience of animals dying from Charbon, and yet the hide was sold and the flesh cooked for food.

Dr. MILFORD—Had known of several cases of persons in Sydney being stung in the face by flies thereby producing Anthrax or malignant pustule.

Mr. DIXON, Chairman—In proposing a vote of thanks quoted a proverb from the Talmud, ‘that many persons are honest because they never had occasion to steal.’ Fining may be a deterrent, but it is better to warn persons what the consequences would be and so prevent people from attempting to act dishonestly, whilst publicity would compel those in the meat trade to take notice of M. Loir’s suggestion.

Nos. 13 AND 14 COMPRESSED-AIR FLYING-MACHINES.

By LAWRENCE HARGRAVE.

[With Plates I. - X., inclusive.]

[*Read before the Royal Society, N.S. Wales, July 1, 1891.*]

THE essential features of No. 13 are a two inch air receiver, four feet seven inches in length; 2952 square inches of floating surface, 2927 square inches of which are in the body-plane, and 22·3 % of the total area is in advance of the centre of gravity; a three cylinder engine of the Brotherhood type is placed astride of the forward end of the receiver, driving a two-bladed screw at the bow of the machine. The whole apparatus weighing 46·86 oz. when it is charged with air at a pressure of 230 lbs. per square inch. Plates I., II., III., IV. show this machine in detail.

The trial of this type of Flying-machine afforded facilities for comparing, in a rough sort of way, the theoretical and actual work done by the engine. A diagram showing time, revolutions, receiver pressure, and reduced pressure can be taken from the stationary machine with the screw on. The screw can then be removed and a pulley substituted so that the engine can lift a weight. The

time of the free flight can be determined with a reasonable degree of accuracy. And the efficiency of the screw engine may be used, though perhaps not quite legitimately, for reducing the enormous theoretical work done by the vibrating engines to an approximately correct amount. A means of making the vibrating engines lift weights is a difficulty not yet surmounted.

The revolution-counter for the free flight consists of a reel of cotton on an axis parallel to the screw-shaft: an empty reel is on the crank shaft secured by a set screw. The turns of cotton that are wound on to reel No. 2, are counted after the flight.

The round turn in the air-pipe is to give it sufficient spring to prevent the play of the engine lifting the valve cover off the back of the valve, the engine being only connected to the receiver by the saddle under the forward crank shaft bearing.

The screw shaft is lighter than the crank shaft and is backed up in several ways, not shown in the drawings, to prevent the engine being damaged when the machine comes to earth.

The time of flight is taken with a sand-glass which has a loop of string at each end of it. The loop at the sand end is put round the right wrist and the other loop is held between the right thumb and the receiver, so that the glass is turned the moment the machine is let go. On the machine taking the ground the glass is put horizontal and the sand that has fallen is timed at leisure. This seems an obvious enough method of finding the speed, but a practical way to do it was not devised previously.

Plate v. represents one of the indicators for recording the receiver and reduced pressures on the chronograph drum, they are adaptable for all pressures likely to be used. The difficulty of making reliable spiral springs of various strengths, was the reason for adopting this form in which it is so easy to insert two, three, or more pieces of the same spring steel to make the amplitude of the diagrams suit the pressures and the length of the chronograph drum. The piece of pipe that forms the foundation of the instrument is held

fast in a clamp when the tin pen has been properly adjusted to the paper. The indicator piston is 11·4 millimeters diameter.

The performance of No. 13, the bow-screw machine, may be summarized as follows:—From two of the weight-lifting chronograms, the efficiency of the engine is determined by Mr. J. A. Pollock to be ·29. The flight was one hundred and twenty-eight feet horizontal with a fall of three feet ten inches. The time of flight was eight seconds. The speed therefore was 10·34 miles per hour. The engine made forty-nine revolutions with a reduced pressure of forty-five pounds per square inch. The stroke of the engine is 1·126 inches and the cut-off at ·8. The area of each piston is ·994 square inches. The total distance swept through by the three pistons is therefore $\frac{1\cdot126 \times \cdot 8 \times 3 \times 49}{12} = 11\cdot03$ feet; and the work done during the flight is $11\cdot03 \times \cdot 994 \times 45 \times \cdot 29 = 143$ ft. lbs. This neglects ·2 of the stroke where possibly some expansion took place.

The screw is right handed, 31·6 inches diameter and one hundred inches pitch. The total surface of the two blades is seventy square inches. A listing moment was produced that one ounce at 32·25 inches to the right of the centre of gravity was insufficient to counteract. The machine listed slightly and turned to port, making a curved course. Two intermediate points were noted over which the machine passed, so that there is a possible error in the distance flown. Taking the flight to have been one hundred and twenty-eight feet the slip of the screw was 69%.

By using ·29 as the efficiency of the 40·5 oz.* machine described in June 1890, the work done by it as tabulated at page 256 of the Proceedings of the Royal Society of N.S. Wales for that year, should be eight hundred and seventy foot-pounds and that of the 74 oz. machine seven hundred and eighty-nine foot-pounds. The foot-pounds for the cross-bow models in the same table should be corrected to 3·8. And on Plate xviii., for stroke 1·27 inches read 2·27 inches.

* Note—The 40·5 oz. machine is now called No. 10, and the 74 oz. one is No. 12.

There are two errors in the Proceedings for 1889, on page 71, line 14, 128 should be 81 : and on page 74, line 38 for "miles per hour," read "feet per second" and correct accordingly.

No. 14 engine and machine, which is shown in Plates vi., vii., viii., ix., is also driven by compressed-air; and the re-distribution of the various parts, with the increased skill in construction acquired by practice are thought to have resulted in a apparatus that, for its weight, will be hard to excel.

The receiver is two inches in diameter and six feet eleven inches in length, and the working pressure 250 lbs. per square inch. The area of floating surface is 3290 square inches, 3074 square inches of which are in the body plane, and 22·27 % of the total area is in advance of the centre of gravity. A vibrating engine stands on the top of the receiver, thirteen inches from the forward end. The cylinder is two inches diameter and 1·28 inches stroke. The wings are of the usual size and shape. The cross-head pin that works the valve also actuates the counter. The total weight of the charged apparatus is fifty-nine ounces.

No. 14 flew three hundred and twelve feet in nineteen seconds, making forty-six double vibrations at 57lbs. per square inch reduced pressure; and, supposing the efficiency to be ·29, the foot-pounds of work in the flight were five hundred and nine.

The flight was above the level of the eye, until the engine stopped from some cause at present unexplainable. It fell to the ground almost vertically. Not the slightest damage was done, the breaking-stick was not even broken, and the machine worked perfectly when taken back to the shop. No. 14 makes ninety double vibrations before the pressure falls to 50lbs., so that two hundred yards is not too much to expect it to fly.

The first trial of No. 14 was a failure, owing it was thought, to the wing arms being too stiff. On taking off one of the wings and holding it firmly by the butt, it was found that $\frac{1}{4}$ lb. hung two feet two and a half inches from the fulcrum and seven inches abaft the wing arm twisted it 6°. Both wings were therefore thinned until the $\frac{1}{4}$ lb. weight twisted the wing tips 8°.

Plate x. is enlarged from the eighth chronogram drawn by No. 14 engine, and it shows the pressures in the air pipe during one double vibration. The receiver pressure being about 125 lbs. per square inch. The chronogram consists of a series of jumps which cease when the receiver pressure falls to about 48 lbs.

The partial interpretation of Plate x. may be stated in this manner, beginning at the left hand side. The vertical scale is pounds per square inch, and the horizontal scale 100th of a second. The reduced pressure reads 47 lbs. as the piston reaches the top of the cylinder and the valve springs to the position that admits air to the top of the piston. Before the piston can be moved down at all the inertia of the wings has to be overcome. This takes time, and the diagram shows it took $\cdot 028$ of a second to start the piston, but during this time the air was coming through the reducing valve and charging the passages and clearance together with the pipe leading to the indicator with high pressure air, this pressure rose to 89 lbs. per square inch before the wings began to rise, and immediately they did so the pressure fell.

It will be noticed that there are two smaller jumps in the diagram as the wings are rising : one is made shortly after the wings begin to move, and the other when the pressure has fallen to the point determined by the tension of the reducing valve spring and the wing area. As these irregularities do not occur when the wings are falling it is safe to assume that they are not caused by any stickiness of the pen, indicator piston or reducing valve.

At $\cdot 18$ of a second from the beginning of the diagram the valve springs to its lower position, the piston remains stationary for $\cdot 035$ of a second, and the pressure rises to 85 lbs. per square inch before the wings begin to strike downwards ; in $\cdot 07$ of a second the pressure has fallen to that to which the reducing valve was adjusted : $\cdot 085$ of a second elapses before the piston reaches the top of the cylinder and the cycle is complete. The double vibration has occupied $\cdot 37$ of a second, during $\cdot 063$ of a second of which the wings were stationary. The mean pressure during the double

vibration has been taken as the reduced pressure: possibly that portion where the pressure rose ought not to have been included.

A consideration of this diagram makes it clear that a uniform reduced pressure is not obtainable without the interposition of a large intermediate chamber between the reducing valve and a vibrating engine. The jumps are just visible in the three cylinder engine chronograms.

It may be mentioned that nine of the successful models described in the Royal Society's Proceedings, representing five distinct types of Flying-machines have been given to the Technological Museum with the object of rendering them at all times accessible to the public, free of charge. The strut of the 48-band machine that made experiments F and G, was used for the 48-band screw machine, and No. 14 is still in the workshop.

It may be said that it is a waste of time to make machines of such small capabilities, and that no practical good can come of them. But we must not try too much at first; we must remember that all our inventions are but developments of crude ideas; that a commercially successful result in a practically unexplored field, cannot possibly be got without an enormous amount of unremunerative work. It is the piled-up and recorded experience of many busy brains that produces the luxurious travelling conveniences of to-day that in no way astonish us, and there is no reason for supposing that we shall always be content to keep on the agitated surface of the sea and air, when it is possible to travel in a superior or inferior plane, unimpeded by frictional disturbances. In other words, the surface method of marine transportation now in vogue is analagous to a man wading along shore through the breakers in preference to either swimming beyond the disturbed water, or walking on the beach.

It does not follow that because the machines described in these pages are of small weight and large area, the insignificant performances of much larger ones of similar proportions are to be scouted. For instance, 400 lbs. weight of tin-tubing, silk, and steel wire would serve to carry one man five hundred yards at seventeen

miles per hour: and such a result, though of no commercial utility would mark an epoch in the art at least as hopeful as the earliest attempts at marine steam propulsion.

A CYCLONIC STORM OR TORNADO IN THE GWYDIR DISTRICT.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[Read before the Royal Society of N.S. Wales, July 1, 1891.]

FROM time to time we read in the American news of the great ravages played there in forests and towns by tornados, and it is quite evident that we have the same enemy in our land, and the only reason we hear less about it is, that population is so thinly scattered over the inland districts, the home of these storms. From many reports which have reached me, I fear we must admit that they are just as terrible in their destructive powers as those known in America; when sound growing trees three and even four feet in diameter are snapped off within four feet of the ground, it is evident that they wield a force before which ordinary town buildings would be destroyed as if by magic. Such being the fact, I have been seeking for information, in order that it may be on record when wanted.

The most complete account has been kindly sent me by Mr. Corbett Lawson, Police Magistrate of Bingara, who obtained the photographs and took a great deal of trouble to follow out the track of the storm to which the following notes apply.

On 23rd February 1891 there were no very threatening weather conditions; an anticyclone rested over South Australia, a low pressure lay S.E. from Sydney, and a tongue of Equatorial low

pressure occupied Central Queensland, extending as far south as Thargomindah. By the morning of the 24th barometers had risen two to three-tenths in South Australia, and the isobars had closed up rather on the coast of New South Wales, while the tongue of Equatorial low pressure had moved to the eastward. At 4 o'clock on that day a violent storm approached Yetman from the Queensland border, with thunder, lightning, and most violent wind, near the town growing trees with two feet of solid wood were twisted off short by it. At Coolatee, thirty miles south of Yetman, large growing trees, three and some even four feet in diameter were broken off short within four feet of the ground, and it was evident that the storm was gathering strength on its course, and in this part it only lasted ten minutes; yet it cut a track like a cleared road through the forest three hundred yards wide. At Piedmont twenty miles south of Bingara the storm track, still clearly cut through the forest, was expanded to three-quarters of a mile wide. It was close to this point that the photographs were taken, although subsequently it was found that the force of the gale had been still greater on a hill near. The storm arrived at Cobbedah at about 6.30 p.m., and therefore it seems to have travelled from Yetman to Cobbedah or almost in a straight line southwards, a distance of one hundred and twenty-five miles in two and a-half hours; or at a rate of progress of fifty miles per hour. The southern part of its track was marked by the most violent effects. Altogether the storm was traced one hundred and seventy-five miles, or from Goondiwindi on the Queensland border to Cobbedah, and probably went much further before its fury was spent.

It is not always possible to find a photographer in the bush where you want him, and Mr. Lawson had to drive one twenty-five miles to obtain the photographs of this storm which I now exhibit, they were taken not where the largest trees were broken off, but near Piedmont about twelve miles north of Cobbedah. At this point it will be seen, that the tops were taken off all the trees in the path of the storm; and as far as one could see, there was

nothing left but bare tree stumps and fallen trees, and so thick was the fallen timber on the road, that it was found quite impossible for the mail coach to pass, until the driver had taken the horses out, and used them to drag trees off the road. The photographs will shew, that every limb that was at all rigid has been broken off, and only those are left which were thin enough to bend to the force of the gale. At first sight there is nothing here to show the gyratory motion of a tornado, for in all three photographs the limbs broken off seem to have been thrown towards the east. In other portions of the track however, the trees twisted off bear unmistakable evidence of gyratory motion, and from the fact that the broken trees are thrown, from west to east while the storm progressed at the rate of fifty miles per hour southwards, it is evident that the wind that did the damage, was blowing across the track, or in other words, was part of a tornado, and further, in order to throw down trees at right angles to the storm path, when its forward motion was fifty miles per hour, it must have been blowing with hurricane force, probably one hundred and twenty to one hundred and fifty miles per hour. This view is borne out by the fact that in parts of its course, as already stated, sound and growing trees, two and even three feet in diameter were broken off short close to the ground, which may be taken as conclusive evidence of the suddenness of the strain, for such a force applied gradually would tear the trees up by the roots.

I am unable at present to give more information about this interesting storm, but I hope that the publication of these notes may lead persons who have the opportunity to observe carefully, and report such storm tracks. The damage done by tornados in populous parts of America is often appalling, and if we cannot do anything to prevent them, we can at least acquire such a knowledge of their frequency and force, that it will be possible in the future to insure against the damage caused by them.

PREPARATIONS NOW BEING MADE IN SYDNEY
OBSERVATORY FOR THE PHOTOGRAPHIC
CHART OF THE HEAVENS.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[With Plate xi.]

[Read before the Royal Society of N.S. Wales, July 1, 1891.]

LAST year I exhibited various photographs of stars and nebulae taken with a portrait camera lens having a focal length of thirty-two inches, now I am able to shew you some of the same objects photographed with the new star camera of one hundred and thirty-five inches focal length. One could hardly realize the extraordinary difference between the two without seeing it. I am also able to shew you the result of taking a star cluster with an enlarging lens which makes the equivalent focal length of the star camera five hundred and sixty-four inches or forty-seven feet. The success of this addition to the star camera is very gratifying, because it shews how much may be added to our knowledge of star clusters by this method of direct enlargement. I find it is much better to enlarge the star pictures in the camera direct than after they are taken, because there are always blemishes in the surface used for the photograph which get enlarged with the picture. The first photograph of Kappa Crucis did not cover a space of one-tenth of an inch square, the star camera makes it eighteen times larger and the enlarging lens three hundred and twenty-four times larger. Where extreme accuracy for measurement is required, as in these cases, the photograph may be again magnified fifty times under the microscope, and the smaller picture will bear no greater power, because it is the imperfections in the surface that carries the image, that limit the magnifying power that can be used.

The photograph obtained with the enlarging lens on the star camera speaks volumes for the stability and accurate motion of

the telescope, which under such a magnifying power gives perfectly sharp star discs. The clearness of these star discs, many of them representing coloured stars, enables us to see distinctly the effect of different colours on the size of the star discs. There are two conspicuous stars, a red, and a blue, the red star to the eye is fully a magnitude brighter than the blue, Herschel called it 9th magnitude, and the blue one 10th magnitude, the red one in the photograph appears of the 11th magnitude or two magnitudes less, and the blue one appears of 9th or one magnitude greater, in other words, the difference in colour as estimated by the eye and the photograph, makes a difference of three magnitudes in the stars.

As I have just stated the photographs exhibited here last year were made with a six inch Dalmeyer Portrait-lens. My object now is to bring before you the state of preparedness of the Star Camera for the work of charting the heavens, as well as some examples of the actual work, plates taken of the dimensions and under the conditions of the plates which will be used for the chart, and only differing from them in that the *réseau* or grating of lines, though ruled and made by the same machine as those that are to be used, has not been tested in Europe, as all must be before they are accepted. These are in fact experimental plates.

The *réseau* I have, was courteously sent to me by Admiral Mouchez, the Director of the Paris Observatory—as an untested sample. The process of testing those to be used being a tedious one, it will take some time before the approved ones are available, but for our present purpose the one I have answers admirably. It consists of a piece of plate glass with a thick coating of silver from solution on one side, on this silver, two sets of lines at right angles have been ruled with a sharp point, which has cut the silver through, the lines are about two-tenths of an inch apart, which is equal to five minutes of arc, and each line is numbered.

The *réseau* is placed face upward in a box, the exact counterpart of the plate holder in the telescope, upon it is then placed a sensitive plate, and the box is closed and put in front of the

object glass of the Star Camera. A small electric lamp of two and a-half candles is then put in the focal point of the Star Camera, and the rays from it pass out from the object glass parallel, and falling on the *réseau* are all stopped by the silver, except those which fall on the lines and figures, and these pass through on to the sensitive plate and mark it. A number of plates are so treated one after the other and stored ready for use in dark boxes. They are all carefully numbered on the glass, and exposed in the Star Camera in order of the numbers. The plates measure $6\frac{1}{4} \times 6\frac{1}{4}$ inches, and the part actually exposed 6×6 inch; of this space 4.7×4.7 inch is the portion which is finally used, that is $2^\circ \times 2^\circ$. Of the margin, rather more than half inch serves as overlap on the plates, and the stars on this can be compared for verification in each adjoining pair of plates. When the plate is developed after exposure, the lines or grating as well as the stars appear.

So far everything is simple and mechanical, but the resolutions of the Conference require, that one set of plates shall have on them all stars to the 11th magnitude, and the other set all stars to the 14th magnitude, and the difficulty in an everchanging atmosphere, and with plates which differ in sensitiveness, is to give the exposure necessary to secure these results.

The Astronomer Royal of England as Chairman of the Committee appointed to deal with these and other kindred questions, has been making experiments on a fairly good night in London. He has come to the conclusion that two minutes will be enough in such weather for stars of 11th magnitude, and thirty minutes enough for stars of 14th magnitude, and that these times must be varied to suit the weather, that is increased if the weather is bad. I am able to shew you three plates, one exposed thirty seconds, another two minutes, and the third thirty minutes, on the well known star cluster Kappa Crucis. You will see that thirty seconds is enough to get images of stars to the 9th magnitude, and that two minutes gives images of stars to the 11th magnitude, and takes in also some of 12th and one of 13th magnitudes.

The plate exposed for thirty minutes is however not so satisfactory, for it should according to the rule, show with defined discs stars of the 14th magnitude of Argelander's scale. In Herschel's monograph on this cluster he has eleven stars of 14th and four of 15th magnitude, of Argelander's scale, of these eight are invisible, six are visible but not measurable, and only one is "measurable," and some stars of even the 12th and 13th magnitudes that are not measurable. The plates were exposed one after the other, on a night that seemed to be uniform, and when the two minutes plate was a success the thirty minutes one ought also to have been. I give the result of this experiment to shew one serious difficulty that besets the work; at first sight the foregoing results look like a failure of the method, but I find that these faint stars in Herschel's list are either much fainter than he took them for, or they are coloured stars. This was proved by taking a photograph of the same object and giving three hours exposure. Even then most of the stars referred to above are far too faint to measure, although they can be seen plainly enough in nearly every instance, and the photograph, hurriedly examined to see if the faint stars were on it, is found to contain at least twenty more faint stars which Herschel did not see. This example will serve to show you better than any statement, the difficulty to be met in following the adopted rule, viz., if two minutes exposure records stars of the 11th magnitude, then thirty to thirty-five minutes should record those of 14th, for here in the case of a well known cluster, with every star recorded by careful observers, it is found that the rule fails, and the question arises, did Herschel over-estimate the magnitude of these stars, or are they coloured. Over nearly the whole surface of the sky we have no record of stars below the 9th magnitude, and therefore no means of finding whether the photographs will really record what is desired, that is stars of 14th magnitude. It is obvious therefore, that more experiments will have to be made upon well known clusters to determine the time necessary for the purpose of making certain of 14th magnitude stars. When that is done however, we shall have

(in the photographs) a vast number of stars appearing as of the 14th magnitude, which the eye cannot see through the telescope, just as I found in Kappa Crucis. The longer exposure given in order to secure visible 14th magnitude stars, resulted in recording a large number of stars photographically of 14th magnitude, but wholly invisible through the telescope. At the recent meeting of the Committee, it was decided on the evidence given by Dr. Scheiner, to extend the time of exposure for 14th magnitude stars to forty minutes, and it is reasonable to expect, since all are interested and working at this difficulty, that it will soon be solved, and times of exposure in different states of the atmosphere agreed upon. At present there seems to be no possibility of dealing with the colour difficulty which is a serious one, as I have already pointed out. Great differences are found also in the sensitive plates, we have tried *Swan's*, *Wratten and Wainwright*, *Field*, *Dodgson's star plates*, *M. A. Seed plates (American)*, and *Ilford plates*; and so far as I have gone, the *Ilford* plates are certainly the best for our purpose.

In my photographs of the Great Magellan Cloud taken with the portrait camera, which I exhibited at the November meeting, the stars owing to their countless numbers appear as blurred masses, and the great and remarkable nebula 30 Doradus is only a white spot. With the Star Camera the picture is enlarged eighteen times, and the stars are separated and brought out sharply defined, while the nebula 30 Doradus is revealed in its wonderful complexity, and shewn to be much more extensive than Herschel made it with his great reflector, so that quite a new light is brought out by the Star Camera, and is thrown on the structure of this object.

There is one thing about this nebula which is very suggestive, some of its loops are round, and all its features seem to be laid out, as if in a plane at right angles, or nearly so to the line of sight; there are no decided elliptical forms, which so commonly appear in nebulae, owing to their circular forms being oblique to the line of sight, and therefore projected into ellipses. If we look at the main

features of Nubecula Major we see that the curves are nearly circles, both those in the main body of it, and in the several star clusters and nebulae ; further if we examine them very closely we find that they are all slightly elongated in the same way ; or in other words the major axes of these ellipses are parallel or nearly so ; they all in fact seem to lie in a plane nearly at right angles to the line of sight. Now just as the sun with his attendant planets, the planets with their moons, and especially Saturn with his rings, shew us that there has been a tendency, as theory would also lead us to expect, to arrange the matter, that is revolving about them in a plane common to all, and as is also evidently the case with spiral nebulae, the matter is arranged in a plane of which the diameter is enormously greater than the thickness, so I think we may safely assume, that the Nubecula Major is a great spiral structure of which we see the greatest diameter, and that its thickness, measured through in the line of sight is comparatively small ; further in addition to the central spiral there are two nebulae, and at least three clusters of stars arranged as spirals, having one character in common with the main one, that is, they are nearly circular, and these are all arranged in space, so that they appear to us, in the same or parallel planes, and near together. It may, I think, be safely assumed that all these are parts of the grandest spiral structure that we know, and that they are all in one plane, because if they are not in the same plane, then, being optically close together and in parallel planes they must be arranged one after the other in a long vista which happens to be in our line of sight ; that is, a series of great spirals, one behind the other, at different distances towards infinity, and all revolving as if on a common or parallel axes ; a conclusion which is highly improbable, and impossible to receive when the simple and more rational alternative of their being all in the same plane is available, which also accords with what we see in other systems. If we assume that all are in the same plane, we can imagine what we should see if transported to some star near the centre. All round us would be an infinity of stars, which on closer inspection, would

seem more crowded in a great plane, and in the same plane we should see certainly two, and probably many nebulae, projected into straight lines, because looked at in the plane in which they revolve; in some directions the stars would appear thinner than in others, because in those, the photograph shews us they do not extend so far into space, and in others owing to the dark spaces in the great spiral, we would see through into the infinity beyond. If you look at the photograph and assume as I have done above, that the whole universe of stars is spread out in the plane of the photograph, you will notice that there would be no difficulty in finding positions from which the observer would see through some of the comparatively dark places as well as other directions in which countless multitudes of stars of all magnitudes would meet the gaze. In fact, his vision would be much the same as ours, in one plane in the heavens, that of our universe, we see an inconceivable wealth of stars, the Milky-Way, with here and there dark spaces, coal sacks—so called—due to the dark rifts such as those above referred to, and turning our eyes gradually away from that plane the number of stars decreases, although they are still abundant.

Now, although even amongst the infinitude of the heavens, we cannot find two star-clusters, or two nebulae alike, we can still find classes, which have many points in common, and I think we have reasonable ground for supposing, that we have presented to us in the Nubecula Major, a universe similar to that in which we are, and that instead of seeing it from within, where it is impossible to make out its form, we are here—with the aid of telescopes, and the still more powerful Star Camera—able to see just such a universe, to trace out a rational explanation of the many puzzling features of the stars, and Milky-Way around us, and to see how such a universe may be arranged.

In reference to another well-known southern object, "the nebula about Eta Argus," it will be remembered that last session I exhibited a photograph of it with three hours exposure, stating that it had not been exposed long enough. On April 9th, 1891,

I obtained a clear night, and an exposure of eight hours—again with the short camera—which brings out a host of stars and shows the Milky-Way with a brilliance it has never been seen to have before, at the same time the nebula, is more distinctly shewn and larger. After a series of trials, I have succeeded in getting several fine photographs of this object with the Star Camera, which make it eighteen times larger than the one I used last year. I have however been unable to get a continuous exposure of eight hours with this camera, still in Plate 77, taken March 18th 1891, with five hours forty-three minutes exposure on a fine clear night, and in others taken about the same time, we have a marvellous revelation of the details of light and shade presented to us in this object, which have never been seen before in any photograph, or by any telescope.

Something like the appearance would be produced, if one took a number of tufts of long-fibred wool, and dropped them one after the other on to a black cloth; as they fell and rolled over one another, they would arrange themselves in curves and lines, through which as one looked down at them, the dark cloth would here and there be seen through tangled wreaths of wool; and in others the cloth would be wholly hidden by the mass of such lines and curves, which would nevertheless be sufficiently distinct to shew how the mass of white was made up; but no description could correctly convey the wonderful detail which the photograph reveals; the general form of this object is the same as in drawings, and in the photographs exhibited last session, but there are certain new features which may be indicated. In the first place, there is evidence here that the nebula is much more extended and the spiral structure more decided, and it can be traced even to the details of the fainter branches. Secondly, the nebula covers a much larger area than that of Orion. Thirdly it proves conclusively that a conspicuous part of the nebula which Herschel drew and described in 1838 has entirely disappeared. I pointed this out in 1872, but as I then used a telescope inferior in power to Herschel's, its invisibility to me, was not proof that it was gone. Now the

Star-Camera is vastly more powerful than Herschel's telescope, how much may be judged from the fact, that in one small space where he could see only one star, the Camera shows ten, and in another place examined by Herschel with equal care, and said to contain four stars, the Camera shews twenty. There can then be no doubt, that in this case a bright nebulous mass, has entirely disappeared in thirty-four years, and it is significant that the part where this nebula was, is now replaced by a dark round spot. I have photographed the object many times with both Cameras, and the dark spot is always there, can it be that in the thirty-four years 1838 to 1872 one of the supposed dark clouds of space has drifted in between us and the nebula. It cannot be a solid body, because the stars are there, but a slight misty body would hide the nebula and not affect the stars very much.

It would be tedious to attempt to describe all that the photograph reveals, especially in the central part of the nebula, but I may say, that while the eye aided by the best telescopes, sees the nebula of fairly uniform brightness, interrupted by certain well-known darker spaces, and especially by that which Herschel called the Lemniscate, this photograph shews a most complex structure, with a great variety of light and shade; and just as in the case of the Theta Orionis, the nebula with its vast folds is shewn to extend farther from the centre, with each increase in the time of exposure, so I find with that about Eta Argus. The southern nebula is however very much more difficult to photograph, and I think it must have some tinge of colour in it, probably yellow, for a photograph of Orion with one hour's exposure is more dense than one of Eta Argus with six hours exposure.

Taken as a whole, the nebula about Eta Argus covers a much larger space than that about Orion, even in these photographs in which the southern nebula, although longer exposed, is comparatively under exposed; while that of Orion is much over exposed.

I have also brought two photographs of the Moon to show you, they were taken on 19th and 28th of May last. As you are all aware,

it is extremely rare to get a night in which there is absolutely no motion, or what is called twinkle in the stars, or in other words, when the Earth's atmosphere is not disturbed by currents of air of unequal temperature. Now until we get such a night and a suitable Moon, it will be impossible to get a perfect photograph of the Moon, for any motion in the air, such as that referred to above, has the effect of enlarging every point of light. A star image for instance may in this way be made two or three times its normal size, and if the stars are close together they are run into one blotch. So on the Moon, all the little details are enlarged and mixed up, so that they cannot be seen; but these photographs are very good and show some features of the Moon's surface which I have never seen in any others, for instance the undulations on the surface of the lunar plains, the equivalent of what on the earth we should call hills and valleys, as opposed to mountains.

SOME FOLK-SONGS AND MYTHS FROM SAMOA.

Translated by the Rev. G. PRATT.

With Introductions and Notes by JOHN FRASER, LL.D.

[*Read before the Royal Society of N.S. Wales, July 1, 1891.*]

V.—SA'U-MANI AND LE FE'E—A 'Tala.'

How their friendship was broken.

INTRODUCTION.—On the road that leads from Taū¹ to Falea-sao, in the Samoan islands of Manu'a, there is now a large *menhir* or 'standing stone,' and thereon hangs this tale. There is nothing remarkable or even interesting in the tale; it only shows that the same causes and modes of story-making have operated in Samoa as in the rest of the world; some uncommon appearance or object in nature excites attention and wonder; imagination comes in and invents a simple but supernatural

way of accounting for it, and ere long the story becomes a traditional myth. So this *menhir* is the stone sinker of the fishing-net of a fabulous hero, Sa'umani. In many parts of Britain, such a stone would bear the name of the 'Giant's Cast,' and the peasants near will show you the mountain side, perhaps a mile away, from which the giant threw it. The Samoans do not seem to know much about giants, but the sinker of a fishing-net is to them a familiar object.

Tala.—They were friends, Sa'umani and Le Fe'e;² they were bosom friends; they followed the same kind of fishing, the casting³ of the net. They dwelt in Malae-a-Vavau.⁴ One day they went down to the sea for their work; they went to fish. Sa'umani looked and saw a man coming up behind the crest of the waves. Then Sa'umani said to Le Fe'e, 'I will throw my net.' Then they two cast their nets. Le Fe'e cast his wrong, but Sa'umani cast his net, and covered the man with the net. Then said the man, 'Friend, why have you entangled me? you have covered me over with your net.' Then Le Fe'e was angry⁵ with Sa'umani; he was jealous because he had not caught a man with his net. Then they went up from their fishing, and agreed to part. Le Fe'e said to Sa'umani, 'I will take my net up inland and hang it along in the bush [from branch to branch]; but you will fish in the sea with your net; go on fishing; you won't catch a man.'

Then Le Fe'e went into the bush and hung his net all along⁶ [the branches], but Sa'umani remained on the shore and turned his attention to the sea. Their companionship was thus severed, and they did not come together again.

Lautala was the name of the man that was caught in Sa'umani's net. When he was caught in the net, he said, 'Why have you thrown me into the net? I am not a fish, but a man.' Then Sa'umani said, 'Who knew that you were swimming in the sea? I thought it was a fish.' Then these two went up inland; for many nights they dwelt in the house of Sa'umani.⁷ Then Sa'umani asked Lautala, 'Whence came you? how did you come here?' Then he answered, 'I am a man from Tonga-Samoa;⁸ I came to seek the family of my father here in Samoa.' Then Sa'umani

said, 'I do not know the family of your father.' Then he remained awhile and went away. Then Sa'umani repented that his companionship with Le Fe'e had been broken off.

That is the Sa'umani to whom offerings⁹ are made, where is the stone in the road between Taū¹ and Falea-sao. They say that this stone was the stone of the net of Sa'umani.

NOTES.—1. Taū is the largest island of the Manu'a group in Samoa, and Taū and Falea-sao were villages in it.

2. *Le Fe'e* is 'the octopus'; he is a prince in the Samoan Hades, which is called the home of Sā-le-fe'e, 'the family of the octopus.'

3. *Casting of the net.* The Samoans, like the other islanders, are keen fishers. They catch fish in various ways—with a large drag-net, with smaller nets, by hooks on a line, by artificial fly-hooks, by fish-spears, by fish-traps; to catch sharks they put out a bait, use a rattle of cocoanuts to attract the 'fish,' and when it comes to the bait, they slip a noose over its body. The nets are made of the stringy parts of the bark of the '*fau*' tree, which are scraped, then spun into cords by twisting them with the hand on the knee, in the usual way; there is however a peculiarity in the making of the meshes of the net. For fishing, two men in a 'dug-out' canoe launch from the beach; the one pays out the drag net; the other, when the boat is far enough out, enters the water and paddles round till he brings the other end of the net ashore; the whole village then joins in hauling the net and its contents to land. This for larger kinds of fish. Other fish that take refuge within the reef are caught with small nets; and, to this end, the villagers rear piles of stones within the reef, or they stretch a net across any opening there. The bonito and other smaller fishes are caught by a fly-hook; the hook is made of tortoise-shell rubbed into shape with incredible industry, and the shank is of mother-of-pearl.

4. *Malae-a-Vavau.* The word '*malae*' is often part of the name of a village; it means 'the open space in the village where the people hold their public meetings.' A general council of natives for one locality, or from several districts, is called a '*fono*.'

5. *Fe'e was angry.* This is a touch of human nature, not peculiar to the Samoans. Fe'e had blundered, and he was angry with the man who was more skilful than himself; so he withdrew in a pet.

6. *Hung it along.* The Samoans do not take their nets inland, as Le Fe'e did. The large and heavy ones they carry on hand-barrows to strong stakes fixed on the beach; there all nets are hung up. But in Rarotonga (Hervey Islands), it is usual to hang up long nets on trees near the house of the fisherman, or near the fishing ground. I imagine that, as Le Fe'e is the prince of Hades, he hangs up his net inland, in

order that it may be a 'soul trap,' to catch disembodied spirits, since he has failed to catch a man alive. See Dr. Gill's "Myths and Songs," p. 171.

7. *In the house of Sa'umani.* Native hospitality never asks a visitor how long he means to stay. A single man, or a company of men on a journey, gets one day's food and lodging, but, after that, is expected to move on. *Nights.* Until recently, the islanders counted by 'nights,' not by 'days.'

8. *Tonga-Samoa.* The conjunction of the two names here is somewhat remarkable; it may indicate that a part of the Tongan group was once occupied by Samoans. Lautala's mother may have been a Tongan and his father a Samoan. The Tongans used to talk of the Samoans as 'very fierce.' Tongan women are much valued in Fiji, because of their fair colour.

9. *Offerings are made.* Offerings of food were commonly made to stones in the Gilbert and the Ellice groups; also on the southern coast of New Guinea. This is fetichism, with an approach to idolatry.

Such offerings of drink and food were made also in the ancient world; cf. sacred stones among the Carthaginians and the ancient Arabs; cf. also Isaiah, lvii., 6.

VI.—SA AND MANU—A '*Tala*.'

A Tale of Man's Disobedience.

INTRODUCTION.—While translating this '*tala*,' we were startled to find it bear so close a resemblance to the Biblical account of the Fall. I therefore made a copy of the tale from Mr. Powell's MSS., and got Mr. Pratt to send it down to Samoa, and to ask some of the old men there if it was genuine, or owed anything to the influence of the white man. An answer came back in these words, translated:—"The '*tala*' concerning Lalo and Manu is a genuine Samoan tale; I have put my name to it. I* am Alama." This Alama is an Upolu man, now seventy years of age, and perfectly trustworthy. His age enables him to know what myths are genuine, for he was a young man when the first missionaries arrived in the islands. It is to be observed also that while our MS. gives the title-names as '*Sa and Mānu*,' his version has '*Lalo and Manu*.' Considering all these circumstances, we also are of opinion that the myth is genuine. Those who have lived long on the islands also know that, if there is any special truth burnt into the native mind, it is this—that sin, which to them means any transgression of the commands of their gods or their chiefs, is sure to be visited with punishment. For reference, I

* This is the form of words used by a Samoan when he signs his name.

print the Samoan text of this 'tala,' arranged so as to correspond with the English, line for line:—

'O le tala ia Sa ma Manu.

'O Sa ma Mānu 'o igoa ia o le ulugā aiga sa mau i Afusigalu.

Na afio ifo ia te i laua 'O Tagaloa-le-Mana mai le lagi,

ma lana i'a, 'o le 'ana'ana-a-lagi, na tuu ia i laua ;

lā te leoleo mā ia ; ua tu'u i le vai.

5) Ma na fetalai i ai, 'Ia oulua fagā la'u i'a lea, ma

leoleo lelei ; nei oulua agaleaga i ai. Ona toe foi lea 'o Tagaloa i

le lagi. A e nonofo laua, ma a'ai ai le i'a, o i laua ma la la fanau.

A ua silafia e Tagaloa. Ona toe afio ifo ai lea,

ma fetalai ane ia te i laua ; 'le tau lenā ; lua te lé usitai mai

10) i la'u tala, au mai la oulua fanau ; ina fa'asaga ia

mata i le pāpāgā ; a e aua lé fa'asaga i luga ;

o mai ia, inā oulua su'e nuu. Ona 'o lea o i

laua ua o'o i Upolu, ua nofo ai i lalo Manu. 'O le mea

na ia nofo ai ua igoa ai ia Lalo-Mānu. 'O a la fanau

15) 'o le *ratu'e*, 'o le *vana*, 'o le *ina*,

'o le *tapumiti*, 'o le *ofa-ofa*, ma mea uma i le sami

e u i lalo mata.

* O'au Alama.

E 'o lé 'o Sā a 'o Lalo, le sa'o 'o le igoa.

'It is not Sa but Lalo, the correct name.'

Alama.

Tala.—Sa and Manu; this is the name of a pair that dwelt in Afusi-ngalu.¹ Tangaloa-le-Mana² went down to them from heaven with a fish for them, the celestial³ 'ana'ana; he left it with them; they two were to keep it for him ; so they placed it in the fresh 5) water.⁴ He said to them, 'Do you two feed⁵ this my fish and guard it carefully ; beware lest you use it ill.' Then Tangaloa returned to the sky. They remained⁶ and ate the fish, they and their children. Tangaloa knew it. Then he came down again, and spake⁷ to them—'The punishment⁸ is this ; since you have not

10) obeyed⁸ my word, bring here your children; henceforth they shall face the coral⁹ bottom of the sea; neither shall you look up; now then, you go and seek¹⁰ for a land [to dwell in].’ Then they went and reached Upolu and dwelt under (‘*lalo*’) Mānu. That is the reason why it was called Lalo-Mānu.¹¹ And their children 15) [were various kinds of sea-eggs], the *valu’e*,¹² the *vana*, the ‘*ina*, the *tapumiti*, the *ofa-ofa*, and all things in the sea whose eyes turn downwards.

NOTES.—1. *Afusi-ngalu*. This name means ‘the place where the waves dash over the reef in spray.’ It is a village near Muti’e.

2. *Tangaloa-le-Mana* means ‘Tangaloa-the-all-powerful,’ or ‘Tangaloa-of-supernatural-power.’ This is one of the manifestations of Tangaloa, the supreme god of the Polynesians.

3. *Celestial*. It is possible that there is here some reference to the ‘heavenly fishes’ of the Zodiac. Some people, of old, regarded the Zodiac as a celestial river. *With a fish for them*; ‘*ma lana i’a*’; *lit.*, ‘with his fish’; the ‘*lana*’ in the text, instead of ‘*lona*,’ implies that the fish was for *his* use, not for *theirs*. Various fishes were supposed to be the special property of the gods.

4. *Fresh-water*. The ‘*ana’ana*’ is a fresh-water fish.

5. *Feed*. The Samoans feed fishes by throwing crumbs to them, and so fatten them for food. The fishes become so tame that they rush to be fed. Small boys amuse themselves by throwing to them little pellets of soap. A fish, suspecting nothing, seizes a pellet, but drops it from the mouth; another fish then seizes it likewise. *He said*; ‘*fetalai*,’ a chief’s word, to ‘speak with authority.’

6. *They remained*. The usual complimentary formula when a Samoan leaves a friend’s house is ‘I am going;’ he answers, ‘You go;’ elsewhere it is ‘I go, you remain.’

7. *He spake to them*; ‘*fetalai ane*’; the ‘*ane*’ is a particle used with verbs and denotes direction ‘towards.’ This time Tangaloa did not speak to them as a friend, but only *towards* them, or concerning them.

8. *Obeied*; ‘*usitai*,’ to give deference to, to comply with. *Punishment*; ‘*tau*,’ reward good or bad; price; payment; punishment.

9. *The coral bottom of the sea*; ‘*pāpāga*.’

10. *Seek for a land*; cf. “So he drove out the man.” Gen. iii., 24.

11. *Lalo-Mānu* is a village at the base of a high conical mountain—Mānu—in Upolu, Alama’s island. This mountain is volcanic, and has an extinct cup-like crater at its top; volcanic action has long since ceased here, but, in Savai’i, it has been comparatively recent, for we know that four or five generations ago, a volcano was still smouldering there; fifty

years ago, the cone of the mountain showed only bare ashes and scoriæ reaching down to the sea and devoid of vegetation, whereas now the whole is thickly covered with bush. *Mānu* means 'to rise on high.'

12. *The vatu'e.* This and the others are varieties of the 'sea-urchin.' The 'vana' is so prickly that victors compelled the vanquished, as a punishment, to toss it up and catch it in their hands. *Vae victis!*

VII.—A 'Tala' ABOUT ATEA.

A Rarotongan account of the Origin of the Sun and the Moon.

—o—

INTRODUCTION.—This is a tale from Rarotonga in the Hervey Islands, and is, at least, amusing, because of the fabulous account it gives of the origin of the Sun and the Moon. In Dr. Gill's "Myths and Songs from the South Pacific," there is a similar tale about the origin of the Sun and the Moon.

Tala.—Ātēa¹ was a man who became a god in the Tahitian group. Buna'auia² was his place in the land of Tahiti. Tangaloa, the god, dwelt in the heavens; all the eastern countries reverence him. At Topoa³ is the sacred place³ which Tangaloa⁴ comes down to; that temple was in Pape-ete.²

Tangaloa looked on the wife of Atea;¹ he went down and spent some time there. Then she conceived. Tangaloa⁴ and Atea had a controversy about the child. Atea said that she was pregnant by him, and Tangaloa said she was pregnant by him. She brought forth a boy. Again they contested; Atea said it was his son, but Tangaloa said it was his son. Then said Tangaloa, 'It is good to divide the boy.' They divided him in two. Then Tangaloa took his half; he cast it into the heavens, and it became the Sun. But Atea took his part and put it under a tub for three nights. Then Tangaloa came to visit Atea's portion; behold it was bad; it stank. Then again Tangaloa threw it into the sky at night and it became the Moon; it was called the 'atu'⁵ of the Moon of Tangaloa. But the spot which is black in the middle of the Moon, when you look at it, that is the part which became putrid, because it was three nights⁶ under the tub. Tangaloa's portion was the head, but Atea's was the hinder part.

NOTES.—1. *Atéa* is the god of Day in the Eastern Islands. Other dialect-forms of the name are *Vātea* and *Wākea*. In Mangaia (Hervey Islands), *Tangaloa* is the son of *Atea*. In Samoa, the common noun *ao-atea* means ‘noonday’; in Tahiti, *atea* means ‘clear.’ To me, therefore, *Vatea* is the ‘clear daylight,’ from the ancient root-word *bha*, ‘to shine’; he thus corresponds with *Dyaus*, *Zeus*, *Jupiter*, in the Aryan mythology.

2. *Buna’avia* is a place in Tahiti, about thirteen miles S.W. from Papeete Harbour. At *Opoa*, a place in Raiatea—another island in the Society group—there is a very sacred and famous ‘*marae*.’

3. *Temple, sacred place*. This is usually a high platform of stones where the bodies of those offered to the gods were placed; in fact, it is any ‘*malu-malu*,’ where a god is worshipped. In Tahiti, the whole was surrounded with a palisade. A grove of trees threw a weird shade over the place.

4. *Tangaloa*; thus in Samoan; but in Rarotongan and other dialects *Tangaroa*.

5. *Group of islands*. We speak of the ‘mountains’ in the Moon; the Tahitians call them the *atu*, ‘group of islands.’

6. *Three nights*. Three and three times three are perfect numbers; cf. the myth of “*Tingilau and Sina*,” note 10.

VIII.—MA-FUI‘E¹ AND HIS SISTER ULU-LE-PAPA.

*The Samoan Vulcan; how Fire was brought from the Underworld;
Introduction of the Art of Cooking.*

INTRODUCTION.—This story has many points of interest for us. *Mafui’e* is the god of earthquakes in Samoa; his abode is down below one of the volcanic islands there; the fire and smoke come from a huge tree which is always burning; he has ‘*taro*,’ yams and other good things to cultivate and feed on; but he prefers to shake the earth when others are making an oven of food; for then the earth cracks, and the food rolls down to him. His classical compeer, *Hephaistos* or *Vulcan*, also has fiery workshops down below some islands, and the tops of the mountains, acting as chimneys or vents, show how busy he is, forging thunderbolts for *Jupiter*, or making a wondrous shield for *Hercules*. As to earthquakes in classic lands, the giants who made war on heaven are responsible for them; to keep one of the biggest of these quiet, the island of Sicily was placed on his prostrate body, his feet to the west, and his extended arm stretching to the two other extremities of the island; the earthquakes are his struggles to free himself from the load that lies so heavy upon him. But this Polynesian myth knows nothing of the working of metals, or of the wars

of the giants. Mafui'e is a peaceful, although tricksome god; he quietly cultivates his 'taro' patch, and, when he is too indolent for that, he robs his neighbour's oven in his own way. Like Vulcan, he is lame; and this story tells how his leg was broken; for he gave his sister in marriage to a mortal up above, who had consequently to become a drudge in his wife's family for a time, as is the Samoan custom; the wife, getting dissatisfied with her brother's company and doings, ran away up to earth and remained there; her adopted son, Ti'i-ti'i, is the hero of this myth, and he it is who makes Mafui'e lame, and does many other wonderful things, now to be related. This child Ti'i-ti'i grew up to be a sharp and courageous lad. He observed that his father always left his home very early in the morning at cock-crow, and was away all day. Curiosity being excited, he, one night, tied the loose end of the string of his own girdle to his father's leg, and so in the morning followed his father, unobserved; the father, taking the road that led down to Mafui'e's land, was barred first by a reed and then by a rock; to each of these he said, 'Split open,' and he passed through; Ti'i-ti'i did the same, and passed down after him. After a little, he discovered himself to his father; and for some reason of his own, resolved to provoke a quarrel with Mafui'e; they fought; Mafui'e lost a leg and an arm, and had to sue for mercy. The youth made good use of his victory; he got from Mafui'e some valuable weather-signs, as we should call them; he brought to the upper-world fire, which had not been known before, and the art of cooking by fire, and the means of making fire by rubbing two sticks together, and taro and yams, which require fire to cook them; these were his spoils of victory.

Ti'i-ti'i's discovery of his father's secret, and his use of the command 'Rock, rock, split open,' bear a striking resemblance to Ali Baba's 'Open, sesame' in the Eastern Tale of the 'Forty Thieves,' and the guiding string, tied to his father's leg, reminds one of Ariadne's clew of thread which she gave to Theseus, to guide his way in the Cretan Labyrinth, when he went there to slay the Minotaur. No one can believe that the Polynesians copied these incidents from anything told them by white men in recent times; we must therefore say that either we have here a similarity of invention in very distant parts of the world, or that these Polynesian 'talas' have a common origin with the myths, märchen, and sagas of European countries.

Another interesting feature, in this 'tala,' is the action of Ti'i-ti'i's foster-mother. She had no child; and so she advises her husband to take a young girl to wife, that he may have 'children by her'; she even procures the girl for her husband; then, when the child is born, she

rears him as her own. In all this we have a parallel to the Bible narrative as to Sarah and Hagar. And yet we cannot believe that the makers of Samoan myths have taken an incident from the Bible and thrust it into one of their own legends, giving it a setting there which is unmisstakeably Samoan in its material and workmanship.

This same tale with considerable variations, is to be found in the "Myths and Songs," but there Mauike is the form of the fire-god's name, and Bua-taranga is the wife of Ru, the supporter of the heavens, and she is the mother of the hero of the tale.

Tala.—The land of Mafui'e¹ was down below;² in it was an immensely large *toa*-tree³ continually smouldering, and there lived the people⁴ of Mafui'e and some other men. The land where the people of Mafui'e lived down below was called Fu'e-aloa, but the road⁵ that went down to it was called Tauai-fu'e-fu'e. By it they could go up above to the people there. These people above at this time, [the time of my story], ate everything raw, but the men down below had cooked food.⁶ [That is not so now; for,] when the men below were conquered, fire was brought up above, and the road was then filled in. Their being conquered was brought about in this wise. Ululepapa was the sister of Mafui'e; her husband was Talanga. She ran away [from Mafui'e's place in displeasure]. For it was the custom of Mafui'e that, when he saw any of the men above⁷ preparing food, he shook the earth violently, and so the food fell and rolled down to him. That was the custom of Mafui'e that Ululepapa was angry with; that is the reason that she ran off with her husband; but Talanga⁸ still went down below to work and make an oven,⁹ uncover it,⁹ and bring the food up; so they had cooked food, but all the rest of the people continued to eat raw food.

Now Ululepapa was married to Talanga, but they had no children. Ulu, [as the custom was,] had to go, day by day, to the sea to fetch salt water¹⁰ [for cooking], and passed by the swamp in which people bathed. Saleatua was the name of this swamp-water.¹¹ One day, Talanga said to her, 'Ulu, when you go to bring salt water, is there no woman to be seen there?' She answered,

‘There is a woman there ; why should you not go to her, and let us have a child.’ When Ululepapa went again to fetch salt water, she saw Ve’a coming to bathe. Now Ve’a¹² was a virgin. Talanga met her. After a while, Talanga told Ululepapa that the woman had conceived. She answered him, ‘It is good ; we shall have a child.’ Then when the time came that she was to bring forth, Ululepapa said to Ve’a, ‘This is the month for you to bring forth ; go you away towards the sea¹³ ; when the child is born,¹⁴ bring him back.’

So they took him up, and Ululepapa had the care of him ; they fed him ; they broke the rock¹⁵ for the child to have water to drink, and to bathe in. The boy grew and was much attached to his father ; he slept perched on his father’s¹⁶ shoulder, and so he was called Ti’e-ti’e-i-Talanga, ‘riding upon Talanga,’ but they shortened the name to Ti’e-ti’e and Ti’i-ti’i. As he grew, they began plaiting¹⁷ a girdle for him ; they continued to plait the girdle, and the boy was crawling ; they had got ten fathoms¹⁸ of it done ; they went on plaiting ; when the boy was walking, they had twenty fathoms ; again they plaited ; thirty fathoms ; again they plaited, and there were forty fathoms. Thus they got to one hundred fathoms. They gave him the whole hundred fathoms as a girdle ; it fitted his body, and there was one fathom left.

The child was now full-grown and used to stroll about. One day he came and said to his mother, ‘What is the reason that we are different from the other people?’ ‘How do you mean,’ said she. He replied, ‘Because we eat cooked food ; but they eat only raw food ; I see it as I stroll about.’ ‘Get away, you tiresome boy,’¹⁹ said she. He came to know that his father was in the habit of going away early in the morning ; so he determined to watch him. At night he went to sleep, but he heard his father going away in the early morning, when the cock crew.²⁰ When another night came, he secretly tied the end of the remaining fathom of his girdle to his father’s foot ; when his father rose in the morning he dragged the boy by the girdle and wakened him. Talanga went out and the boy followed him ; he reached the place

of reeds²¹ and he heard his father saying 'Reed,²¹ reed, split open; I am Talanga; I am going to work.' Then the reed opened and Talanga went down. The boy came and said, 'Reed, reed, split open; I am Talanga; I am going to work.' The reed split open, and the boy went down. He heard his father saying, 'Rock,²¹ rock, split open; I am Talanga; I am going to work.' The rock split open and Talanga went down. The boy came and said, 'Rock, rock, split open; I am Talanga; I am going to work.' He went down and saw his father working. There were plantations of taro and other things there, but there was no taro up here in those days. The boy saw a swamp-apple²² and took it up. He was not yet observed by his father. The boy saw the smoke of the fire of Mafui'e, who was getting ready some food. He bit a piece out of his apple, and threw it at his father. The father thought it was a bird which had dropped the piece of apple. Then he threw the apple. His father looked round at the boy and said, 'How did this boy come here? he is going to be troublesome.' He asked his father, 'What is that smoke yonder?' He answered, 'That is the fire of Mafui'e; don't make a noise, or presently both of us shall be killed by Mafui'e; why should we die?' The boy said, 'Not at all; I'll go and get some fire from his oven.' The boy went and snatched a brand, tapped it [to make it burn brighter], then threw it down, and put it out. This he did to aggravate Mafui'e; again he snatched another firebrand, threw it down, and put it out likewise. Again he went; then Mafui'e called out, 'You there! where do you want to take the fire to? you come too often; if you are able, take that large firebrand there, if you want to make a fire.' He pointed to a very large firebrand. He at once took hold of the large firebrand and was about to carry it away, when Mafui'e, seeing that the boy was strong enough, called out, 'Leave that fire!²³ leave it!' He left it. Then he went to the home of Sa-le-Fe'e;²⁴ there was a woman there, Si'i-si'i-mane'e, whom Mafui'e was in the habit of visiting. Ti'i-ti'i went there, and the girl married him. He was about to take the girl away; Mafui'e heard of it, and was angry; he shouted 'Stand! stand!

let us two make an agreement to fight to-morrow.' Then he went and made his oven; when he uncovered it, Mafui'e shook the earth, but nothing fell.²⁵ Then Talanga said, 'Let us go up.' The boy replied, 'You go on ahead, I will come up to-morrow.' The father did not know that Mafui'e and he were about to fight. Talanga went up and Ti'i-ti'i went to Sa-le-Fe'e.

On the morrow he came back with the girl that Mafui'e constantly visited. Mafui'e said to him, 'Shall we fight²⁶ first, or box, or take hold of one another?' Ti'i-ti'i replied, 'You want to do women's work, fighting and boxing, and shirk the wrestling.' So he went and caught him, wrestled, and threw him, broke his arm; caught him again, broke his leg.²⁷ One leg and one arm were broken. Then Mafui'e shouted, 'Let me live, lest you get no signs; leave this leg for me, that I may work for you and make offerings of food to you; and leave this hand to make signs for you; and you may come and take up the fire.' Then he left him and Mafui'e gave the signs²⁸ thus:—

If there is an earthquake at noon, that is a sign for war;

If there is an earthquake at night, that is for famine;

If there is an earthquake in the morning, that is for a storm.

'And I will make offerings²⁹ to you in your country; I am your conquered servant.'

Then Ti'i-ti'i went up above, and with the firebrand he struck the different trees; then he took it by the end and threw it to Fiji³⁰ and the Atafu³¹ group and to Niuē; there is a mark on the places where the firebrand fell.

This is how they first got fire³² to cook food; they also got fire-wood and the wood to get fire from³³ by rubbing. He beat many trees³⁴ with the firebrand,—the '*fau*,'³⁵ the '*fua-fua*,' the '*ma'o*,' the '*tamannu*,' and others.

In due time Mafui'e came up with his offering of cooked taro and other things. The land to which he came with his offering was called Sa-amo,³⁶ that is, the shoulder-stick of the offering, on which he carried it up. He begged of Ti'i-ti'i, if Ti'i-ti'i had any love for him, to shut up the road so that people might not go up

and down by it. Ti'i-ti'i had compassion, and he closed the road so that there is now no traffic that way.

NOTES.—1. *Mafui'e*, the Sāmoan god of earthquakes. When there is an earthquake, the Sāmoans cry out, 'Ua Mafui'e,' 'oh! that's Mafui'e.' In the Maori dialect, 'puia' is a volcano. *Ululepapa* means 'the entering into the rock.'

2. *Down below*, that is, below the surface of the volcanic island Taū, in Manu'a.

3. *Toa tree*. This is a very hard wood, indigenous to Samoa; it is the *Casuarina equisetifolia*, common in Taū, rarer in Upólu and Savai'i, but quite common in Rarotonga (Hervey group) and in other islands. When once lighted, the 'toa' wood burns on and smoulders, like touchwood, until the entire log is consumed.

4. *The people of Mafui'e*; cf. the Cyclops and the Cabiri.

5. *The road*. This is well known to classical mythology in the stories of Orpheus, Hercules, Castor and Pollux, &c., cf. '*itque reditque viam toties*.'

6. *Cooked food*. There was no fire there, no taro or yams, no cooking, until Ti'i-ti'i conquered Mafui'e.

7. *Any of the men above*. This must refer to those who occupied the higher parts of Mafui'e's land, for the inhabitants of earth above had, as yet, no means of cooking food.

8. *Talanga went down still*. In Sāmoa, a man, when he marries, has to go and live in his wife's family and work for them. At the end of the first year, the husband and his wife go to their own home. Till then, the husband is a veritable slave to the mother-in-law. Coming home at night, tired and weary with work, he will hear her say to him, 'What do you sit down for; you are lazy; go and get some cocoa-nut.' And he goes!

9. *Make an oven*. The oven for cooking food is a necessary appendage to every house, at a little distance from it, and protected by a fence. A sufficiently large hole is dug in the ground; fuel is placed in it, and on the fuel a lot of round and hard stones; the fire is kindled and an hour is allowed for this heating process; the stones are then spread out, and the food to be cooked,—bread-fruit, taro, fish—is laid upon the stones and covered up with green leaves; this steaming process goes on for another hour, until the food is ready; the cry then is *fu'e le umu*, 'open the oven'; 'uncover it.'

10. *To fetch salt water*. Salt water is used for all kinds of cooking. To prepare taro for the table, the leaves, being easily broken, are wrapped together into the shape of a hollow bundle; a liquid consisting of the expressed juice of the cocoa-nut and salt water, half and half, is poured into the middle of it; the whole is then tied up and cooked. The dish when ready is much relished; it tastes like spinach. Pudding of grated

cocoa-nut is also cooked with salt water; fish, fowl, &c., that are to be cooked, are first wrapped up in banana and cocoa-nut leaves.

11. *Swamp water.* The islanders are often in the sea water, but its saline particles irritate the skin; hence the need of fresh water to bathe in. If they can find a swamp near the shore, they scoop it out to some depth with cocoa-nut shells, and bathe there.

12. *Ve'a* is also the name of a bird; the *Rallus pectoralis*. Such an incident as this in *Ve'a's* history is nothing uncommon in Samoa, and is no disgrace. A sister goes to a sister's house to nurse her in a time of illness, and becomes the husband's second wife; but she occupies an inferior position, and is something like a concubine. The word used to express this is *fa'a-nofo*, 'to cause to sit up or live with, as wife,' and, as a noun, it means 'a second wife' introduced by the first wife. In the story, Ululepapa makes all the arrangements for her husband; for she is childless.

13. *Towards the sea.* One of the first things the mother does is to plunge into the sea with her babe, and bathe.

14. *When the child is born*; lit., 'when the navel-string is cut.'

15. *Broke the rock.* That well is still to be seen. See p. 86.

16. *Perched upon his father.* *Ti'e-ti'e* is a verb that means 'to be seated on something above the ground,' 'to be perched aloft.' Mothers carry their children on the hip, but fathers on the shoulder or astride on the neck. *Ti'e-ti'e*, being his father's pet, was often allowed to fall asleep there.

17. *Plaited a girdle.* This must have been a girdle of string, so long as to be wrapped many times round the loins. The Samoan girdle, 'titi,' is made of 'ti' leaves, fastened on a stout cord. The 'lava-lava,' worn by Samoans, is now of calico, originally of 'siapo' (native cloth); the 'malo,' used in war, is narrow. The boy's girdle in the text was the 'malo.'

18. *A fathom*, in Samoan, is 'gafa'; it is measured by the full stretch of both arms.

19. *The boy is tiresome.* 'Ah! 'o le tama lenei fa'alavelave, 'this boy is a hindrance.' Samoan children, it seems, do ask inconvenient questions.

20. *When the cock crew*; *toa*, 'a cock'; 'a warrior.' The Samoans have a native breed of domestic fowls, small like the Bantams. Even the imported Brahmapootra stock becomes, after a few generations, small as the 'toa.' The only indigenous animals in Samoa were the cock and hen, the small black rat, the lizard and the snake. The snake is not venomous.

21. *Reed*, 'u,' *rock*, 'papa.' I understand the command 'Open, sesame,' when addressed to the 'rock,' but I do not know why a 'reed' should be ordered to split open. But see note 34.

22. *Swamp apple* or 'Malay apple' is the *Eugenia Malaccensis*; it is

allied to the 'guava.' The boy, biting a piece out, threw it at his father, but failed to attract attention; he then threw the rest of the apple.

23. *Leave it.* Mafui'e seems to have at first disdained the boy, but becomes imperious on seeing this proof of his strength.

24. *Sā-le-Fe'e* is the Samoan Hades, the home of the 'race of Le-Fe'e.' The story puts it near to Mafui'e's quarters.

25. *Nothing fell.* I take this to mean that the tricks, which Mafui'e practised successfully on others, had no power over the boy.

26. *Shall we fight?* The challenge is three-fold—to fight with weapons, or with fists, or to wrestle; Ti'i-ti'i, being the challenged, has the choice, and rejects weapons and fists as feminine accomplishments.

27. *Broke his leg.* Vulcan too was lame, but he got his lameness in a different way.

28. *Signs; an earthquake at noon.* With this compare,

"A rainbow in the morning is the shepherd's warning;

A rainbow at night is the shepherd's delight."

The Samoans also have adages about the weather. Earthquakes are severe and common in Upólu. In Savai'i, there is an extinct volcano which, according to tradition, was active about four generations ago (see Note 11, p. 75). In Mr. Pratt's own time, a small volcano showed action in a village about eight miles from his residence.

29. *The making of offerings* is a token of subjection.

30. *Threw it to Fiji.* In Samoan tales, Fiji seldom fails to appear; and yet the Fijians are Melanesians. *Niué* is 'Savage Island,' to the east of Tonga.

31. *Atafu* here is probably one of the islands of the Tokelau or 'Union' Group, to the north of Samoa; this group, which was recently annexed by Britain, consists of—Atafu, Nukunono, Fakaofu, and Oloenga.

32. *They first got fire.* The first getting of fire is a world-wide tradition, but the manner of getting it varies; cf. the story of Prometheus.

33. *Firewood and wood to rub.* The text here is—'ua maua a'i fo'i fafie, ma la'au e si'a a'i le afi'; *lit.*, 'we have got firewood and the stick to rub with to produce fire.'

34. *He beat many trees.* This seems to mean that he made the wood of those trees suitable for producing fire when rubbed; that is, he put *latent* fire in them, so that men might not henceforth have to go down to the Underworld to get fire, but might obtain it from these trees by rub-sticks. See Dr. Gill's "Myths and Songs," p. 57, where also, as here, only four trees are mentioned. In his myth about 'Māui, the Third' (p. 70), it is a post of the dwelling that first opens to give descent to the world below; this may explain the 'reed' of Note 21.

35. *The 'fau' tree* is the *Hibiscus tiliaceus*; the 'tamanu' is the *Callophyllum inophyllum* of Botanists.

36. *Sa-amo*; 'amo' is the stick on which a burden is carried over the shoulder.

Addendum.

NOTE.—Mr. Powell's MS. has the following note to this Solo :

'O LE SOLO O ULULEPAPA.

"The Song about entering into the Rock."

March 27, 1871. 'This afternoon, on my return from Fiti-uta with Taunga, I visited the place celebrated in this Solo, viz., Tauai-fu'e-fu'e and the Le-vai-na foa-i-le-papa, 'the water which burst from the rock,' both situated in the land known as the Fu'e-aloa. The place where the 'U' reed is said to have grown has nothing peculiar, neither has the site of Talanga's house, which is close by, but the 'Vai' or water in the rock is remarkable. It is a short distance from Tauai-fu'e-fu'e in a north easterly direction. It is a piece of black scoriaceous rock, irregularly square, about two feet wide each way and eighteen inches above the ground; it has a round hole in the middle, three feet deep, and containing about thirty inches of good clear water. This is said to be the well which Ululepapa hewed in the rock to give drink to her child.—June, 1871. The exact measurements are:—Two feet eight inches deep in the middle; on its north side, the stone stands two feet above the ground and is at that part three feet wide; it slants down to a height of only nine inches on the south side, where it is eighteen inches wide.

ON A WAVE-PROPELLED VESSEL.

By LAWRENCE HARGRAVE.

[With Plates XII., XIII.]

[*Read before the Royal Society, N.S. Wales, September 2, 1891.*]

DURING a forced delay in the Flying-machine work, time has been found to make a model that any one can see has a future before it.

If you turn to the paper "On the Trochoided Plane" that was read on August 6th, 1884, you will find these words. "The

“power may be abstracted from the swell of the ocean by means of the trochoided plane, thus :—Take a flat float and rigidly connect a plane at some distance below parallel to the float, and it will be found that the plane and float alternately pull each other in the direction of propagation of the waves, the result being that the apparatus progresses through the water faster than a float without the plane attached. If the plane is fixed vertically at right angles with the float, the resultant is in a direction contrary to that in which the waves are moving.”*

This model will be seen from the drawing (Plate XII.) to be a punt-like structure, ballasted with lead to a draft equal to half the depth. The displacement is about five pounds.

Under the fore-foot is a clamp for securing a boom† that carries at its extremity a thing like a balanced rudder with the post horizontal. This is called the *plane-propeller*. A piece of wire projecting horizontally aft from the boom-end serves as a stop. The plane-propeller is free to move on its axis either way, until it is stopped by a piece of string and india-rubber connecting the stop and the propeller blade.

The axis of the plane-propeller is about half the model's length in advance of the stem, and at a sufficient depth to be always immersed.

There is a vertical axis to the bearings of the plane-propeller, so that the stop and propeller can be rotated horizontally. This enables the model to turn circles or go with the wind and sea aft. As the model rises and falls with the sea, the plane-propeller acting in less disturbed water, makes a resultant greater than the wind friction *plus* the skin resistance.

* Photographs of these two models will be found in “The Evolution of the Flying-machine” in the Library of the Royal Society of N.S. Wales.

† It will be obvious that in practice the boom will not project, as in this experimental model, from the forefoot. The vessels will be of great beam, with long overhanging bows, at the extreme end of which the propeller will be situated. (Plate XIII.)

The wave is the power stored in the water by the wind acting at a distance from the locality where we use it. The propeller is made to act on the water in the trough of the sea where the particles are oscillating towards the wind; and the deeper the propeller is below the crest of the waves the less movement the particles of water have in that portion of their orbits where they are moving in the direction that the wind is blowing.

The wind friction is insignificant if we remove the complication of obstructions usually opposed to it. The skin resistance increases as the square of the velocity, and is the principal factor in determining the speed of the vessel.

It is perhaps unnecessary to point out that there is but one moving part. That when the plane-propeller is doing its best work, the vessel rises and falls without pitching and scending. That no spars are carried. No engine and coal space is required, and the captain and cook constitute the crew.

The rising and falling on an even keel may seem paradoxical, but it is nevertheless true. Suppose the vessel to be in the trough of the sea with the plane-propeller to windward; as the wave reaches the centre of buoyancy of the forebody the vessel tries to pitch but the tendency is resisted by the plane-propeller actuated by the weight of the afterbody. When the crest of the wave reaches the centre of buoyancy of the afterbody, the vessel tries to scend, but is prevented by the weight of the forebody acting on the propeller. When the crest of the wave is under the forebody the apparatus is a first order lever, and a third order lever when the crest is under the afterbody.

NOTES ON A SPONTANEOUS DISEASE AMONG
AUSTRALIAN RABBITS.

By M. ADRIEN LOIR.

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[Read before the Royal Society of N.S. Wales, September 2, 1891.]

DURING the month of April last, the Chief Inspector of Stock, Mr. A. Bruce, was good enough to send me thirty rabbits, to be used at Rodd Island in conjunction with the experiments which I am carrying out there with the co-operation of Mr. E. Stanley, the Government Veterinarian. After an interval of some days from their arrival, one of the rabbits died and during the six days following upon this first death, I found seven dead bodies in the cage in which they were kept. I then placed each of the remaining rabbits in separate cages, so as to allow the disease to take its course in those animals in which it was in the process of incubation, while preventing those infected from spreading the contagion among the others. Two days later another death occurred among the rabbits thus isolated, but this was the last, and since then the disease has completely disappeared. I caused the cage to be carefully washed with a strong solution of carbolic acid.

Two months ago I received a further consignment of thirty rabbits which I placed in the same cage as that in which the first mentioned rabbits were confined. Up to the present date no deaths have occurred, nor have any signs of the disease manifested themselves. With a view to elucidating if possible the causes of the malady which affected the first consignment of rabbits, Mr. Stanley made enquiries at Narrandera, whence they were obtained, but so far as he was able to ascertain the animals were in a perfectly healthy condition when despatched, and no disease was known to exist among the rabbits in the district.

Having regard to the vast importance to the community of any information bearing upon disease among rabbits, I have carefully investigated the malady to which attention is now directed, and I venture to lay the results of my observations before the Royal Society.

Symptoms of the Disease.

It is exceedingly difficult to distinguish any very marked symptoms. The rabbits affected do not lose flesh; they die without convulsions, the head in a natural position, and the whole body in the sitting posture usually adopted by rabbits in captivity. A little diarrhœa is usually apparent.

Post-mortem Examination of a Rabbit having died of the Disease.

A little peritonitis is noticeable. The cortical substance of the left kidney is of a dark black colour, and the kidney itself, when cut, appears discoloured on a level with the pyramids. The other kidney is very much congested and presents large black spots on its surface. The spleen is dark and small. The liver shows some white patches. Lungs congested. No pericarditis. Little diarrhœa.

When inoculation is affected by the subcutaneous method, a small quantity of white matter is found at the spot of inoculation.

The disease is easily transmitted by means of inoculation, and death ensues within forty-eight hours of the operation, when a fresh cultivation or the blood of a dead animal is inoculated.

Post-mortem Examination of a Rabbit which died forty-eight hours after inoculation.

Lungs very red, congested with patches of hemorrhagic black. The spleen black but small, with white patches on the surface. White patches on the surface of the liver. Pronounced diarrhœa. Some white matter at the spot of inoculation. Fibrinous peritonitis, pericarditis and pleurisy.

The disease may be inoculated from a rabbit to an animal of another species, but the rabbit seems more susceptible to the disease than any other animal. I inoculated a fowl which is still

alive (one month after inoculation). I also inoculated two Guinea-pigs, of which one died three days afterwards, and the other showed no further effect than an abscess at the spot of inoculation.

The disease can be easily communicated through the intestines by means of infected food, but in such cases death occurs only after a rather extended period.

The blood, the spleen, and the urine have all been found to contain the germs of contagion.

Microbiology.

The blood and the organs always contain a small microbe. This microbe is readily coloured with aniline colours, especially good results having been obtained by using Læffler's blue. The blood of a rabbit having died of the disease when inoculated in ordinary veal broth produces a cultivation. As soon as eighteen or twenty hours afterwards the liquid loses its clearness. After a few days the cultivation collects at the bottom of the tube and leaves above it a clear and transparent liquid. The alkaline reaction of the broth does not alter. This cultivation shows a microbe of the shape of a *Streptococcus*. The pure cultivation inoculated in another rabbit produces death in about forty-eight hours and the same microbe is found in the blood. These cultivations when kept for two months exposed to the air have been found virulent for rabbits. On the 20th July a rabbit was inoculated with a cultivation, which had been kept since the 18th of May, and died on the 23rd, about sixty hours after inoculation.

Temperature at time of inoculation	...	39° 5	C.
,,	24 hours after inoculation	40° 2	,,
,,	40 hours after inoculation	40° 7	,,
,,	52 hours after inoculation	41° 5	,,

Post-mortem Examination of a Rabbit having been inoculated with the Cultivation.

A small quantity of matter at the spot of inoculation. Fibrinous peritonitis generally distributed. The left kidney black and discoloured when cut. The other kidney very congested. Con-

gestion of the intestines with petechiæ. Petechiæ at the base of the heart, spleen black and small, lungs red. The blood of this rabbit when placed in broth, gave a cultivation of the same microbe in twenty-four hours. This microbe develops readily when placed in gelatine, in which it produces a white train along the inoculation puncture. The microbe appears to be exclusively aerobic, that is to say, that it cannot be cultivated in inert gases such as carbonic acid.

Experiments of Contagion.

I have attempted to ascertain whether it was possible to transmit the disease by cohabitation. Up to the present time out of six rabbits exposed to contagion by placing them in a cage with the dead bodies of other rabbits which had died of the disease, one has succumbed to the effect of the malady after five days.

Judging from the appearance of the microbe as seen through the microscope, from the aspect of its cultivation, and from the physiological reaction which it produces in animals, I believe that I have discovered one which is the cause of a spontaneous disease in rabbits not hitherto described, and it is from this point of view that I have thought it would prove of interest to the Royal Society.

While discussing a matter relating to rabbits, I would like to direct attention to the fact that, contrary to the generally accepted belief in Europe, the Australian bush rabbit is smaller than the rabbit sold in the markets of Paris. I give below the weights which I find entered in my note-book, of the rabbits used for experimental purposes at the Pasteur Institute during the years 1886 and 1887 :

2 Kilog.	820 gram.	...	about	...	6 lbs. 1 oz.
2	„ 480 „	...	„	...	5 lbs. 2 ozs.
2	„ 700 „	...	„	...	6 lbs.
*1	„ 800 „	...	„	...	4 lbs.

These rabbits were chosen at hazard, for the purpose of certain experiments which I was then making, from among the rabbits which are always kept on hand in M. Pasteur's Laboratory.

For purposes of comparison I append particulars of the weights of rabbits arriving from the bush, well-fed and in healthy condition :—

1 Kilog.	340 gram.	...	about	...	2 lbs. 14 ozs.
1	„ 600 „	...	„	...	3 lbs. 7 ozs.
1	„ 200 „	...	„	...	2 lbs. 10 ozs.
1	„ 700 „	...	„	...	3 lbs. 11 ozs.

NOTES ON SOME CELESTIAL PHOTOGRAPHS RECENTLY TAKEN AT THE SYDNEY OBSERVATORY.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

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In order to complete our photographic apparatus, it was necessary to obtain such an attachment to the Star Camera, as would serve to record highly magnified images of double stars, the moon and other objects. This has recently been added, so that now we can record double stars photographically on a scale which gives ample dimensions for accurate measurement, viz., thirty-six inches to one degree, or 0.01 inch equal one second of arc. It will be remembered that the enlarging lens mentioned by me in June last made the scale ten inches to one degree, and gave a result as large as a direct photograph in a telescope forty-seven feet long, but the new one makes the telescope, so far as the magnifying power is concerned, one hundred and seventy-nine feet long; on a favourable night one would with this get a picture of the moon twenty inches in diameter. We have taken portions of the moon upon this scale, and I think you will agree with me when I say that these photographs are finer than anything which has been done,

or at least published before. In one of these the well-known lunar crater "Copernicus," appears more than half an inch in diameter, and a mass of detail is revealed in and about the crater altogether new in photographs of the Moon.

Another shows "Eratosthenes" and the Apennine Range of lunar mountains, with the very remarkable elevated plateau which extends away from them towards the south, and forms the divide between the Bay of Tides and the Sea of Vapours.

I will not take up your time in describing the details, you can see them in the photographs in much less time than it would take to describe them, and certainly much better. I may however mention, that one of those dark markings which can be seen on the moon's surface is very conspicuous here; it looks something like a shadow, and is bounded by roughly parallel lines and straight sides, there is however nothing to cause such a shadow, and from the fact that it is there in all the varying lights, as the sun rises over these hills and vallies, it is evident that it is a peculiarity of the surface of the moon, which from some cause does not in this part reflect so much light as in other parts. The dark space is about thirty-five miles wide and one hundred and twenty miles long, and stretches not only right across the great spur of the Apennines referred to above, but also over a great part of the Sea of Vapours.

Another photograph includes about half the Sea of Showers with the craters "Eratosthenes" and "Plato," as conspicuous objects. On this sea much detail of surface is depicted, the undulations of the surface, 'little hills &c.,' being very conspicuous.

Still another photograph takes in perhaps the most rugged part of the moon's surface. The most conspicuous crater here by its position on the terminator as well as by its actual size is "Clavius," one hundred and forty-two miles in diameter, its towering mountainous ring running up in places to eighteen thousand feet.

This object is beautifully shown, the curious string of smaller craters which stretch across the floor being very clearly defined;

it is without doubt one of the finest bits of mountain scenery in the moon. Another photograph shows the "Mare Crisium" with the sunlight just at the right angle to show its surrounding mountains. This sea measures two hundred and eighty miles one way, by three hundred and fifty the other, and in the photograph the undulations "hill and valley," and the small craters in it are clearly shown. One of the minor ridges runs parallel with the whole length of the western boundary, like an inner range. Another photograph shows the moon eight days old with "Copernicus" and other features very well defined, but on a smaller scale, and still another view brings out conspicuously the markings of full moon.

Leaving the work done with this new attachment to the Star Camera, I should like to show a fine photograph obtained three days since with the Star Camera. It has, you see, in the centre of a surrounding multitude of stars, (for it takes in a part of the Milky-Way) a small but beautifully defined nebula. I am not yet ready to go fully into detail about this, suffice it to say that this is called the Trifid Nebula, from the fact that three dark lines lead up to a very conspicuous triple star, and has attracted a good deal of attention from Sir J. Herschel and others. The photograph which is beautifully clear, while preserving some of the leading features presented to the eye in the telescope, and recorded by Herschel and others, reveals so many more that the whole aspect is changed. These details are of the same character as those in Eta Argus and others that I have photographed, and are totally different from those which the eye aided by the most powerful telescope can make out. Indeed photography is altering our view of what Nebulæ in detail are like, so that in speaking of pictures of Nebulæ it is very necessary to say how they were produced. The sensitive film seems to grasp details which the eye cannot see, and I am disposed to think that this is not owing to the faintness of the light, but to some inherent difference which the Camera can and the eye cannot see.

SOME FOLK-SONGS AND MYTHS FROM SAMOA.

Translated by the Rev. G. PRATT.

With Introductions and Notes by JOHN FRASER, LL.D.

[*Read before the Royal Society of N.S. Wales, September 2, 1891.*]

SIX *Solos* ABOUT THE KAVA (PLANT AND DRINK).

INTRODUCTION.—From this bunch of *Solos*, and from the narrative which precedes them, it is clear that the Polynesian gods, like those of Olympus, are anthropopathic; for they have in heaven above the same rules of precedence and the same ceremonious deference to authority which are observed among chiefs and ordinary mortals on earth below; indeed the gods are called ‘chiefs’ in these myths, and, when they speak, they themselves use, and are addressed in, chiefs’ language, that is, words which the Polynesians reserve exclusively for their chiefs. Then the gods eat and drink as mortals do; they have fish up there and taro and yams; and when they want to drink, have they not the famous *kava* plant, and a bowl, strainer and cup of their own, and near by is the heavenly ‘*vaitina*,’ with its never-failing supply of fresh water. For a time, these possessions were theirs alone to enjoy, but when the worm-progeny of the Fue-sā had been fashioned into men by the supreme Tangaloa, and when the Sā-Tangaloa,—the kith and kin of this supreme god—had begun to visit the earth below, and the sons of men had learned how to ascend to heaven above, the privileges and possessions of the gods came down to men and were shared by them; certain fishes were given to them; taro was surreptitiously conveyed from above; and in these *solos* we learn how the *kava* drink became known to mortals.

It happened in this way. In the Polynesian heaven, there is only one god, Tangaloa, a quiescent being, who loves peace and tranquillity; but he has many ways of manifesting himself, according to the nature of the work which he purposes to do. Each of these manifestations is a Tangaloa, with an attribute added to the name to show his special function. Others again are his sons by mortal mothers—not sons of the supreme Tangaloa, who rests in the Ninth Heavens,—but begotten by those energizing partners of his nature whose duties or inclinations sometimes took them down to earth. All of these gods, whether human or divine, had the right to

attend the *fonos* or sacred councils in the heavens, and were called the Sā-Tangaloa, "the family of Tangaloa." At every *fono*, the very first observance was the *kava* cup. The drink was prepared from the heavenly plant in the same way as is described in these *solos*; the cup of ceremony, when filled, was handed by some Polynesian Ganymede, first to the god highest in rank; he drank of it; then to him who was next in dignity; and so to all the circle, the order of precedence being carefully observed. Then, when all the members of the council had tasted thereof, the 'grand consult' began. Such was the order of their doings in heaven above. But, on one occasion, Tangaloa-le-Māna, that is, 'the miracle-working Tangaloa,' whose seat was the Eighth Heavens, happened to be on earth; and, desiring some *kava* to drink, he sent his attendants to heaven to get the requisite appliances; they brought down not only the bowl, strainer and cup, but the whole of a *kava* plant which they had, in their hurry, torn up by the roots. Of this, Tangaloa threw away the most part, as it is only the 'rhizome,' or root stem, that is chewed. Pava, a mortal, who saw all that was done, watching an opportunity, gathered up the portions which the god had rejected, and planted them; they grew luxuriantly, and thenceforth men enjoyed the god-like drink. Meanwhile, however, Le-Māna had called for fresh water wherewith to make his beverage. The rain came down in torrents at his will; it rained night and day; it rained even in sunshine; and Pava was swept away by the flood, but escaped drowning.

In these six *solos*, the myth-makers do not expressly say that they regard Pava's appropriation of the stray pieces of the *kava* as theft and sacrilege, but it is clear that they look on him as an unprincipled man, a man of bad character; for they call him 'a bad man'; they record his irreverence towards the god A-Ui; and they bring him to a bad end; for he is compelled to leave his country and wander from place to place, the all-searching eyes of Tangaloa-a-Ui following him everywhere. It is this god who now takes up the action, Le-Māna having apparently returned to heaven. Although A-Ui was partly of human parentage, he was noble to look on and godlike, for he was tall as the ridge pole of Pava's house, and could work a miracle on Pava's child; and when Pava and his wife had to flee in dread, A-Ui's eyes were like a flame of fire in pursuit of them.

When Tangaloa-a-Ui first went to visit him, Pava was at work some distance from home; for, while the islanders may have their houses near the sea, the *taro* patches which they cultivate are often several miles inland, among the volcanic soil formed on the slopes of the mountains.

When the messenger told him that there was a chief in the house who wished to see him, he thought he would make a preliminary survey of his visitor ; so he wrapped himself up in a *taro* leaf, and on it he floated down the stream till he was opposite his own house ; then Tangaloa, knowing the deceit, put forth his hand, seized the float, and was about to eat it up like a sandwich, when Pava saved himself by giving voice. Now, among ourselves, children in the nursery still read of Tom Thumb, and how, one day, when he was resting on a dock-leaf, a hungry cow, with one sweep of her tongue, carried leaf and him into her capacious stomach. So here ; Pava must have been a very small man, if he could conceal himself in a *taro* leaf and use it as a boat.

Meanwhile, the women of the household had been preparing the *kava* bowl for the guest. Etiquette requires that, while this is going on, a respectful quietness should prevail in the house, for there is a sort of sacredness in the process ; but an unruly son persisted in romping about, and at last he upset the *kava* bowl. Tangaloa, in anger, struck the boy with the stem of a cocoa-nut leaf ; the stroke cut him in two ; then, seeing Pava's grief, he joined the parts together again, and the boy became whole as before. Frightened by this exhibition of power, Pava and his wife took to flight, swam to Tutuila, a distance of seventy miles, and at last settled in Upolu, where Pava became the war-god of the district of Fale-alili.

But A-Ui's adventures were not yet over. Leaving the *kava* ground of Sauā, he sauntered along and picked up a few companions. With them he formed a plan to capture the beautiful princess Sina, a Polynesian Thetis, when she came up from her sea-green cave to bathe in the fresh water near the shore. In this they succeeded, and Sina became the wife of Tangaloa and the mother of both spirits and men.

Le-Fanonga, "Destruction," one of her sons was a lad ill to manage and restrain—as 'destruction' usually is. He found his way up to the councils of heaven, and his unwonted presence there caused a sensation. The gods, to get rid of him, imposed on him something like one of the labours of Hercules, and sent him to pull up the 'fierce *kava*,' about which I can tell you no more than what its name bears on its face—a 'fierce *kava*' which it was dangerous to touch. But Le-Fanonga overpowered it, and dragged it in triumph into the presence of the gods. So it became his property.

But as Fanonga lived, so he died—still an unruly boy. If ever a Book of Metamorphoses, written by some Samoan Ovid, should be discovered, I am sure that Fanonga's end will be found to have a conspicuous place

in it. For, one day, he and a brother were sent to prepare an oven of food for their father; the boys made up the oven and then went off to enjoy themselves in surf-swimming. They stayed so long at this, that, when they came to open the oven, the food was seen to be spoiled. Then Tangaloa, in anger, seized a red-hot yam and threw it at Le-Fanonga; it struck his body and marked it over with reddish spots, and so he became the Samoan owl!—which also has red spots.

And now a few words as to the kava plant itself, its region and mode of growth. The name has various forms in Polynesia—*kava*, *yava*, *‘ava*, *kawa*, but the Fijians say *yangona*. By botanists it is called *Piper methysticum*—‘the intoxicating pepper’—natural order *Piperaceæ*. It grows as a shrub, at the most six feet high, and the stem about an inch in diameter; the leaves are acuminate and heart-shaped, and are either green or more or less tinged with purple; it has small and axillary spikes of flowers. The extreme base of the stem, and the rhizomes or creeping stems, are the parts from which the beverage is prepared; these are used when fresh, but they are also dried and stored, and yet retain their properties. The plant is propagated by offshoots for cultivation. The drink has an exhilarating and then a narcotic effect on most of the natives who use it. They take it at the evening meal; for a time they sing and show themselves happy under its influence; they then fall asleep, and sleep, it may be, for twelve hours. When they awake, their faithful spouses have prepared some warm food for them, taro or the like; this sends them to sleep again, and thus the effects of the debauch wear off. To use it habitually to excess causes a white scurf to gather on the skin, and I am told, that it is sad to see the emaciated form and scabby skin of habitual and heavy *kava* drinkers. In the Hervey Group, it was only the chiefs, priests and the old wise-men, that drink of it. The use of it is now forbidden both there and in Tahiti and the Society Group. To a stranger, the taste of this fermented liquor is odious, resembling the flavour of soap-suds, mixed with magnesia and rhubarb.

In heathen times, in the Hervey Group, no response from the gods could be obtained unless the officiating priest had first been presented with a bowl of *kava*. Then he fell into a frenzy, and the oracle was announced in a most unearthly voice. With the *kava*, cooked taro and fish were given to the priest; without them, the necessary state of frenzy would not appear.

In the Under-world too, the *kava* is known, but there, according to Rarotongan belief, it is the exclusive property of Miru, an inexpressibly ugly hag, who cooks the ghosts in her horrid oven and eats them. To

explain her use of it, I extract the following from the Rev. Dr. Gill's "Myths and Songs from the South Pacific," p. 161 :—"The grand secret of Miru's power over her intended victims is the *kava* root. The three sorts of *kava* known in the upper world were originally branches of this enormous root ever-growing in Avaiki. Miru's four lovely daughters are directed to prepare bowls of this strong *kava* for her unwilling visitors. Utterly stupefied with the draught, the unresisting victims are borne off to the oven and cooked. Miru, with her son and peerless daughters, subsist on these human spirits. The refuse is thrown to her servants, Akaanga and others. Such is the inevitable fate of those who die a natural death, that is, of women, cowards, and children. They are *annihilated*; but some of the wise men say that they live again, after Miru and her followers are done with them."

As to the 'habitat' of the plant, our *solos* declare that its original home, when it was brought down from heaven, was the group of Manu'a in Sāmoa, and that it was carried thence to the other islands of Sāmoa, to Tonga and Fiji in the one direction, and to Tahiti in the other. By them its horizon is thus limited to Fiji on the west, and Borabora of Tahiti on the east. But we know that it spread not only to Tahiti but to the Hervey Group, to all the Society Islands, to the Marquesas, and even to the Hawaiian islands in the far north-east. Also, when the first missionaries went to the New Hebrides, they found the plant cultivated and used in all the islands of that group; but it is not known in New Caledonia, the Loyalty Islands, or in New Guinea. In New Zealand the drink is not used, but the plant, in one or other of its varieties, is employed in various religious ceremonies, such as the removing of *tabu* and the performance of a rite equivalent to baptism. In some of the smaller islands of Polynesia, the drink is prepared solely as a libation to the gods; and even in Sāmoa it was mainly the chiefs and elderly men that used it; and in Tahiti the scurf spots on the body caused by its habitual use were considered marks of high rank. In Samoa, the youths, when they were fully tattooed and thus entered on the privileges of men, were allowed for the first time to drink the *kava* at entertainments.

To prepare the drink for use, the furniture required is a supply of the root, a bowl, a strainer, a cup, and a good array of strong teeth in human jaws. The *solos* describe the mode of preparation;—the plant is pulled up, root, stem and branches; the twigs, branches and the greater part of the stem are broken off; for it is only the lower stem and rhizomes that are used; the portion selected is beaten on the ground to clear it of earth; it is also scraped and cut into pieces; the skin is then torn off with the teeth; if not to be used immediately, the pieces are thrown into the house,

that they may be dried and stored there; if the drink is to be made at once, the collected heap of *kava* is handed over to the kava-chewers, who sit in a circle and are mostly young people—virgins preferred—from fourteen to twenty years of age, the belles of the town. These crush it between their teeth, and, after it is masticated, they place the fibre in the *kava* bowl,—a large wooden vessel kept for the purpose; when there is enough of the masticated root there, pure water is poured into the bowl, and the whole is stirred with the hand; if allowed to settle for a little, it speedily ferments; the liquid in the bowl is then strained with *pulu* (cocoa-nut) fibre, and borne to the guests in a cup—a cocoa-nut, which, from saturation and frequent use, often looks as if made of tortoise-shell—to the highest in rank first. The cup-bearer must be a skilled master of the ceremonies, for any violation of precedence is a mortal insult. In presenting the cup to any chief, say Sanga, he says with a loud voice “O Sanga, here is *kava* for you,” and, while Sanga drinks, the whole company strike their hands on their thighs in applause; and so, with similar observances, the cup passes round to all the circle of chiefs. The highest chief, when he received the first cup, before drinking of it, always poured out a libation to the highest god, Tangaloa-i-le-langi. The drinkers in the New Hebrides were not so well-mannered as that; for, although at the beginning of the feast, they poured out a bowlful to the gods, yet each man, as he drank, used to spit out the last mouthful, saying “Here, gods; that’s for you!”

To us the chewing process does not seem a pleasant way of preparing a beverage for others to drink, but some of the South American Indians prepare maize beer in the same way; and, in Formosa, rice and barley are chewed for the same purpose.

The *kava* plant is slow of growth; for this reason and probably from some sense of its sacredness, its use was somewhat restricted in Sāmoa and Tahiti, but in the Tongan and some other islands, the natives still debauch themselves with the drink. The plant loves a shady place; in heaven it was *lafita’i*, ‘hidden away,’ ‘concealed’; in Sāmoa it is grown under the shade of other trees; in our *solos*, it is poetically described as ‘standing on tiptoe and reaching up to kiss the blossom of the *fasafasa*’ and other pretty trees, by which it is surrounded. Its first place of growth, according to these *solos*, was Sauā, an easterly point in Taū, one of the Manu’a islets. The people of Savai’i got it from there by purchase, the price being a fat and plump mother hen, as the third of these *solos* tells us. Then it spread to Upolu, Tutuila, and the other islands of the Samoan group; and everywhere found congenial soil and became prolific; it spread even up the sides of the mountains till it almost reached their

backbone. These myths also say that the influence of the trade winds is favourable to its growth, and that it grows best among stones and rocks.

In speaking of the spread of the plant to the distant isles of Fiji, Rarotonga, and Tahiti, the poet finds it convenient to say that it was carried thither by the bird of Fuipau, a fabulous hero; for how else than by divine interposition could it have traversed so many miles of ocean as lie between Samoa and Tahiti; spreading its bushy wings out to the influence of the trade winds, this ministering bird conveyed the slips of this precious plant swiftly and safely to far-off Polynesian lands, where also it found congenial soil.

There are some points in these *solos* which brings us into contact with myth-land in other regions of the globe. I have already said that they show the Polynesian gods to be anthropomorphous, endowed with the shape, character, conduct, activities, passions, pursuits of ordinary men, while at the same time they retain their rank and power as gods, for even those of them that are of semi-divine origin can work miracles and bring retribution on those who show despite to them. The gods in heaven above are a 'family'; they are Sā-Tangaloa, 'the Tangaloa family'; they assemble in council in 'fale'ula,' the 'bright home' of the highest Tangaloa, and sit in a circle while they deliberate; they depart to execute the *fono's* behests, each in his own sphere; they visit earth and return again to heaven; they partake of food and drink down below, just as they do in their own realms above; for up there too they have *fono*, 'cold food,' to eat—the heavenly fishes—and they have the *kava* drink, made from the heavenly plant; they have birds of the air to do their bidding, just as we have beasts of the field; and in heaven above, the gods are swift to know and to requite the evil that is done among men. In all these respects the Polynesians are in harmony with the Aryan notions about the heaven of the Indian Meru, the Grecian Olympus, and the Norse Walhalla. Walhalla has its brilliant 'hall of joy,' Gladsheim, as Le-Langi has its Fale-'ula, 'bright house' or 'house of joy'; there Odin's crew had their feasting and wassail, although more riotously, it must be confessed, than the banquets of cloud-compelling Zeus on lofty Olympus, where nectar and ambrosia were the only fare; and while the pantheon of the Hindūs is made up of gods of the atmosphere more than is the Polynesian, yet there is a general likeness between them; for Brahmā too is a quiescent god like Tangaloa; he is the impersonal first cause, but, as Brahmā, he is the creator of all things; Tangaloa, in like manner, becomes Tangaloa-le-tutupu-nu'u, 'Tangaloa the creator of lands,' but leaves his other functions to Tangaloa-le-Mana, T. savali, T. asi-asi-nu'u; so also

Brahmā's place in the active affairs of the world's life is taken by Vishnu and Siva in the Hindū mythology.

Then, again, in Olympus, the eagle is the messenger of Zeus, and, at his bidding, carries off the beautiful youth Ganymede to be a cup-bearer in heaven; and the dove is the messenger of Venus; so Tangaloa's bird is the Tuli, 'the plover'; which assists him both in works of creation and ministration; and other birds and fishes are sacred to the Polynesian gods.

In one of our *solos*, Tangaloa-le-Mana is made to say—

"When the kava is distributed, I must be first;
That your lives may be washed clean."

May be washed clean; this is the literal meaning of the words, 'fa'alanu a'i la'u soifua.' Le-Māna, the god 'of supernatural power,' therein promises that if his devotees will take care to give him due honour at their feasts and in their daily life, he will see to it that their lives are washed clean. To a Polynesian, such an idea is indigenous, certainly not derived from Christianity. An islander is from his youth familiar with the irritating and blistering effects of salt water and sunshine on his skin; hence to him the preciousness of pure fresh water in which he may bathe and be clean; he knows also that any disobedience, any disrespect, to the gods is sin in his own eyes and in theirs; hence he always endeavours to honour them that moral guilt too may be washed away. But here I must draw rein on my pen lest you should think that it is about to indite a sermon.

There is only one other point which I should like to notice. In the classic Hades there is a river

"Whereof who drinks
Forthwith his former state and being forgets,
Forgets both joy and grief, pleasure and pain."

That Lethe, "the river of oblivion" has a merciful function, for it wipes out the sorrows and head and heart aches of the past. But in the Polynesian Avaiki, as you have heard to-night, the strong stupefying *kava* drink is devised by an ugly monster that she may feast herself and hers on the departed, ghosts though they are; the cup is presented by four attractive and lovely maidens, lovely to look on, but they feed on the spirits of dead men, and the drinking of the cup issues in destruction. Now we have all heard of the cup of Circe and the songs of the lovely Sirens; "Circe's pocula" and "Siren strains" have become by-words. Circe too worked by plants and drugs and incantations, and could thus change men into swine and other beasts; she too, like Miru, was horrid to look on, and is said by some to have been the daughter of Hecate, the

queen of hell; the Sirens, on the other hand were beautiful maidens, "the entanglers"; for, sitting on rocks on the sea shore, they lured sea-faring man to a miserable death by the sweetness of their song. In other classic stories, he who goes down to the infernal regions alive on pious errands, must eat nothing there, else he is numbered among the dead and ne'er returns to the light above; so too in the Polynesian mythology. And thus, as I think, myths prove themselves to have a common origin, and seem to have been borne by the human race from some central birth-land into the farthest regions of the globe—not merely into the plains of India and to the shores of Greece and Rome, but to Scandinavia and Finland and Lapland in the extreme north as well as to the smallest islands of the eastern Pacific; and thus even myths, simple though they are, tend to prove that the whole world is akin.

MR. POWELL'S SUMMARY.—This Sa'umani is the same person as in the previous tale, but he is here associated with Pava, a man who comes under the displeasure of Tangaloa. Mr. Powell in his MS. notes, states that he received this tale from Palenga, a son-in-law of Tauga-nu'u, the legend-keeper of the island of Taū. The references in the 'solo' are very obscure, as is often the case in Samoan poetry, and Mr. Powell explains the whole story thus:—

"At a period when the place subsequently called Sauā was known only as Anga'e-tele, the god Tangaloa-le-Māna came down from heaven with two attendants, named Telemu and Malifa'i. They went a-fishing for him. There were no hooks, lines, or nets in those days; the only way of catching fish was by beating the hands together in the water, and so seizing the fish. In this way, they caught a fish, the *manini*, and brought it to Tangaloa. But he wished to have some *kava* to drink with it, and, as there was then none on earth, he sent them up to heaven to fetch down a root of it. They, however, pulled up the whole plant, brought root, stem, branches and leaves down with them. Tangaloa then scattered the superfluous pieces round about, on the spot where he was, and they grew up luxuriantly among the rocks and stones. Then the god desired water to mix the *kava* with, and immediately rain poured down from all quarters in such quantities as to cause a continual stream—a flood—of water. They had also brought down from heaven a cup (*ipu*), a bowl (*tanoa*), and a strainer (*tau-aga*). Thus *kava*, the drink of the gods, was first introduced to earth."

"The subsequent part of the 'solo' has reference to Tangaloa-a-Ui. After this god, who was the child of a human mother, Ui, had in his youth been tended by Tuli and the other servants of Tangaloa-i-le-langi, he resided till manhood near the spot where he had been adopted, having the heavens for a house and a cocoa-nut tree for shelter. From this circumstance, the place of his early sojourn was called Fale-niu, that is,

‘the house of the cocoa-nut tree.’ It is situated some distance south of Sauā on Taū.”

“When adult, the god left this place, and travelled along the beach till he came to the locality where the *kava* was growing, which Tangaloa-le-Māna had caused to be brought from heaven. It had grown so well and so thickly that the leafy branches enveloped his head and shoulders as he passed, and that gave to the place the name of Sauā, because the leaves and branches of the *kava* plants enveloped his face; its previous name was Anga’e-tele, ‘the great east.’”

“Tangaloa then turned aside to a house, belonging to a man whose name was Pava. The only person there was a girl, Pava’s daughter. ‘Where is your father,’ asked Tangaloa-a-Ui. ‘He is inland at work,’ she said. ‘Go and tell him a visitor is here; say there is a chief in the house.’ The girl went with the message, and told that there was a chief in the house. ‘What sort of a chief is he,’ asked Pava. ‘He is very tall, reaching to the ridge-pole,’ was the answer. ‘Very well,’ said he; ‘go, you and your mother, take down the *kava* and I will follow by-and-by.’ A stream flowed over the land, down by the side of the house where Tangaloa was sitting. Pava therefore took a *taro* leaf, turned up its sides so as to form a screen for him, seated himself on it, and floated down the stream, intending to inspect his visitor before presenting himself before him. He seemed to think that it would not be known that he was concealed in the *taro* leaf. When he was floating past the house, Tangaloa put out his hand, seized the leaf with its contents, and assumed not to know that it was a man that was in it. So he said, ‘Here’s some food to eat with the *kava*; how brown it is! how sunburnt!’ To which Pava replied, ‘Are you going to eat a man?’ Tangaloa then says, ‘Why then did you come quizzing me? Pava is a bad man; he is quizzing [other] men.’”

“Pava makes some apology and then the *kava* is prepared. Pava had three children; one of these was playing about and making a noise. Tangaloa said to Pava, ‘Tell your boy not to make a noise.’ Pava paid no attention. Again Tangaloa said, ‘Tell the child to be quiet, on account of the *kava*.’ Pava gave no heed. The child kept on playing, until at last he upset the *kava* bowl. Tangaloa then said, ‘Did I not bid you restrain the boy?’ Upon that, Tangaloa seized the boy, and gave him a blow with the stem of a cocoa-nut leaf; the blow divided the boy in two. ‘Here,’ said he—taking up the one part of the body—‘this is your share, and this is mine,’—putting down the other part before himself. Pava was grieved; he would not touch it. Tangaloa then said, ‘Did I not tell you to forbid the boy? You came quizzing me, and thinking I had no power; give me here your part.’ He immediately took the two parts, united them and the boy was restored to life!”

“Pava was now seized with fear, and said to his wife, ‘Let us go; we’ll leave this place.’ Then they started off through the bush in a westerly

direction, and came down to a place—Pava—on the south side of Fale-tolu. Here they looked back and saw that Tangaloa had still his eye upon them. It seemed as if he were close by, although he was still at Sauā. They therefore came north till they reach a place which is a little inland from the west point; this is also called Pava. Looking up, they perceived that Tangaloa was still watching them. Again they fled, took to the sea, swam to Tutuila, landed at Tafuna, proceeded inland, and stopped at a place now named Pava-‘ai-‘ai. Looking back, they perceived that the eyes of Tangaloa still followed them. Again they fled, and finally arrived in the district of Fale-alili [in Upolu], at a spot now called Pava. Here they were out of sight of Tangaloa-a-Ui, and here Pava settled and became the war-god of Fale-alili. Their ensign in war is the taro-leaf cap, in commemoration of Pava’s having floated down the stream on a ‘taro’ leaf.”

“After the departure of Pava, Tangaloa-a-Ui soon left Sauā; he travelled westward and came to a place where is the head-quarters of the La’e family. Here was a man named La’e who was rubbing his hatchet on a stone. He saluted Tangaloa-a-Ui as he passed, but kept on rubbing his axe, [saying], ‘You two are come; where did you come from?’ Tangaloa replied in displeasure, ‘What do you mean by continuing your work while you address me? have you no eyes to perceive that I am a chief?’ This speech frightened La’e; he stopped his work. And from this incident it is that a Samoan discontinues any work he may be at, when a chief is passing. The proper token of respect is to suspend the work till the chief has passed.”

“Tangaloa passed on and came to Maiā, the village west of Fitiuta in Taū; here he met three persons named in the *solo*, Tuitalea, Malu and Taafanua. The last he found at Maia; not far off, at Tua-ma-Alo, he met Malu, and next Tuitalea. They four went and sat down on a platform, where they conversed together. As they were sitting there, they were suddenly startled by a great shouting, which came from a cave below, at a little distance off. Tangaloa-a-Ui inquired, ‘What is that?’ ‘It is the shout of the young men,’ answered his companions, ‘bringing up, on a hand-chair the beautiful princess Sina, the daughter of Sa’umani, to bathe.’ ‘Oh! I should like to get her for my wife,’ continued Tangaloa; ‘how can we manage it?’ They then consulted together, and resolved on a plan,—to make a net the meshes of which would be large enough to admit the head of Sina, but too small to allow her to escape through them; to spread this over the entrance to the cave; then Tangaloa would stand at a distance, and cause such a cloud to rise as would make the young men think it was heavy rain. They followed this plan. The net was spread and fastened to a large fern; Tangaloa took his station seaward in front of the cave, and when the young men came up with their royal burden, seeing, as they thought, the heavy rain, they put down their burden and retired for shelter; the lady, coming forth to take her bath, was

caught in the net, became the wife of Tangaloa, and was subsequently the mother of men and spirits. Of her children Le-Fanonga was the first born and Ta'e-o-Tangaloa the next."

"After the birth of Ta'e-o-Tangaloa and Le-Fanonga, Tangaloa-a-Ui constantly attended the councils of heaven, and was therefore called Le Folasa, 'the prophet.' When Ta'e-o-Tangaloa was old enough, his father used to take him up with him, but left Le-Fanonga below, for he was very unruly. This boy, however, learnt from his mother where his father and brother were gone to, and made his way up to heaven. His presence there caused consternation, and, in consequence, he was sent to bring to the council the *'ava fe'ai*, 'the fierce kava,' in the expectation that he would perish in doing so. But he went to the place where it was, and subdued it, and brought it back in triumph. The council then deliberated, and resolved to send Tangaloa-a-Ui down with the *ao* (supreme power) and all kingly privileges, including the *fale-ula* (palace) and the *fono* (the holding of councils for deliberation and justice). Tangaloa-a-Ui gave the *ao*, or royal dignity and universal rule, to Ta'e-o-Tangaloa, who was therefore the first on earth that held the title, dignity and authority of *Tui o Manu'a ma Sāmoa atoa*, 'king of Manu'a and the whole of Samoa.' Le-Fanonga retained his portion of the *'ava fe'ai*."

"After these things, Le-Fanonga and La'a-mao-mao, another son of Tangaloa, made an oven of food for him, that is, according to the Samoan fashion, they prepared the yams, put them on the hot stones and covered them up; but they then went to sport on the rollers which break over the reef. When the oven was ready, Tangaloa, their father, sent to call them to uncover the oven. They said, 'Wait a while till the yams are better done.' Again he sent. After a while, they came and uncovered the food, but it was all burnt; the yams were spoiled; some were red hot, others blackened. Tangaloa said, 'Bring them here; let me see them.' They were brought; then he was very angry with Le-Fanonga and La'a-mao-mao; he seized one of the burning yams and flung it at Le-Fanonga so that his body was burned reddish in several places; his emblem is the 'owl,' and that is the reason why the Samoan owl is so red! At La'a-mao-mao he threw a blackened yam; that struck his neck which was thus blackened and elongated. His emblem is the 'black heron,' and that is why it is black and its neck long! Le-Fanonga flew to Sale-i-moa in Upolu and became its war-god. La'a-mao-mao, in the form of the black heron, flew to Manono and became the war-god there."

In a note on the *Solo o 'Ava a Tagaloa-le-Māna*, Mr. Powell explains:—"This solo has reference to the first planting of the *kava*. Tangaloa-le-Māna came down to earth, and, desiring some *kava* to drink with the fish which his two attendants, Telemu and Malifai, had caught for him, he sent them to heaven to bring down such portions of the *kava* plant as would be required for the preparation of the beverage; but they brought him not only the root, but also the stem and the leaves. Then Tangaloa

broke up the stem and threw the pieces about him. A man of the place, whose name was Pava, planted them, and thence the *kava* plant subsequently spread throughout Samoa. This happened after the time when the *ao*, the *fale'ula*, and the *vaitina* were brought down from heaven by Tangaloa-a-Ui."

IX.—SA'UMANI AND PAVA—*A Solo.*

How the Kava plant came down from the heavens.

1. You two will go a-fishing ;
2. With your hands strike the water, making a hollow sound.
3. They got only one fish,
4. A *manini*, from the salt sea.
5. Tangaloa lifts it up and tears off the skin ;
6. Tangaloa lifts it up and throws it aside ;
7. [For] he desired some kava to drink with his cold food.
8. "Now then, O Telemu and Malifai, [he says],
9. You two will run up to the heavens ;
10. There the kava grows hidden away [in a shady covert];
11. You will pull it up with its stem ; [the ground ;
12. You will break off [the part to be used] and beat it [clean] on
13. You two will peel off the bark ;
14. You will tear off the skin with your teeth until there is enough."
15. Tangaloa carefully examined the kava,
16. For the kava was pulled up with its woody stem.
17. Where does that kava [now] grow ?
18. It grows in Sauā and Malae-'Ava ;
19. Towards the sea is Sauā-e-'Ava ;
20. Landward is Malae-'Ava ;
21. These are the spots on which the plant came down.
22. Tangaloa longed for some fresh water, [the kava cup.
23. For they had brought down the bowl and the strainer and
24. Heavy rain came down ;
25. Rain, rain at night :
26. It rained everywhere ;
27. Oh, it was wonderful :

28. Rain fell and yet the sun was shining :
29. Rain-in-sunshine came down :
30. Pava was swept on by the swollen waters.
31. [While] you come down, [O rain,] you know not
32. Who is the man you will sweep away,
33. Where it [the sun] shines, and the man will be carried to.
34. [And why ? because] Pava is a bad man,
35. He makes fun of men.

Tangaloa speaks.

36. "While you are all chewing the kava, [O Pava,]
37. Warn and admonish
38. And exhort your boys,
39. Because Tangaloa's kava [is preparing]":
40. Tangaloa had said, "The boys make a noise";
41. But the boys were not forbidden.
42. Tangaloa caught hold of the boy ;
43. He struck him with the stem of the cocoa-nut leaf ;
44. Each of them got his half of the boy ; [my kava."
45. "That is yours, this is mine ; this will be food [to eat] with
46. But Pava did not kill [his half] because of his love.
47. Then Tangaloa took hold of the boy, joined him together, and
he lived.

* * * * *

48. O foolish companions of Sa'umani, [rain.
49. [Because] the cloud was spread [there], you thought it would
50. O Tuitatau of Sualoa, Malu of Tua-ma-Alo,
51. And Taafanua of Maia,
52. Sit round, sit in your circle ;
53. Adjust, adjust [to proper size] the meshes of your net :
54. Spread our your net on the branching leaves ;
55. Now take up, take up your net ;
56. You have not made your meshes for the fish of the deep,
57. But you have made them the size for men—
58. To catch Sina, the virgin princess,
59. Who brought forth spirits brought forth men.

O !

X.—THE KAVA OF TANGALOA-LE-MĀNA—*A Solo.**The growth of the Kava; the Preparation of the Drink.*

—o—

1. O kava, kava, grow up, thou kava.
2. Where shall the kava grow ?
3. 'Mid the stones it shall grow ; it shall grow on the rock ;
4. It shall stand tiptoe and bite off the fruit of the *fala*;
5. It shall stand 'mid the leaves of the *fasafasa*,
6. And struck by the leaves of the *fagafaga*.
7. Its pith is white like the *sigano* blossom ;
8. It will soon be thrown down [for use];
9. Command that it be collected,
10. Nor let there be any kava left.
11. Those who are to feast are all together [here].
12. Cut it off with its roots ;
13. Do you scrape it out ;
14. Take it to the kava chewers ;
15. First of all, get [ready] the fibre-strainer ;
16. Rinse out the mouth with a green cocoa-nut ;
17. And collect together [the portions chewed].
18. His bowl was the leaf of the wild *taro*;
19. His cup is of *tava* wood ; [le-Māna.
20. And [the kava] is pressed out with the strainer of Tangaloa-
21. Where did that kava grow ?
22. It grew at Sauā and Malae-'Ava ;
23. That is the spot on which the kava came down.
24. When the kava is handed round, let my [cup of] kava be first;
25. I am Tangaloa-le-Māna.
26. When the kava is distributed, I must be first,
27. That your lives my be washed clean.
28. As this precious song [declares],
29. The kava grew up at Sauā.
30. Ever since, this kava has grown there.

O !

XI.—‘O LE VA O LE ‘AVA—*A Solo.*

‘The Contention about the Kava’; the Spread of the Kava plant.

—o—

1. Sauā is a land to the east ;
2. [Thence] bring the kava [plant] and portion it out
3. In our one group of Samoa ;
4. That [also] is the kava [plant] of Fiji and Tonga ;
5. And it reached even to Borabora. [about.
6. Let the kava plant get up early in the morning and sail all
7. O Savai‘i and Salāfai,
8. Don’t you contend with me [about it, says Sauā],
9. For we know whence it came.
10. [Thou did’st buy it from us] ; thy price was brought ;
11. It was brought but not enough ;
12. Thereupon thy repentance grew up,
13. And [then a sufficient] price was brought—
14. The brood mother hen was brought.
15. Then the kava [plant] was given [thee by us] ;
16. It was planted inland ;
17. It grew, it was prolific ;
18. It spread in Fale-A‘ana ;
19. The kava spread to Tua-masanga ;
20. And also to the ruling lands there.
21. O chiefs, Aui-matangi,
22. Do you consider this :
23. Towards the east is Fale‘ula ;
24. There is the kava in its place of growth.
25. Although there is causeless contention [about it],
26. Yet Sauā is well known
27. That the kavas grew there of old.
28. Come here, Fua and Fanga,—
29. You two whose child was punished—
30. There is the kava which is to be drunk.
31. Wake up the boys [to go] to the shore [a-fishing].
32. They started up ; it was evening.

33. Go to Lua-le-manga ;
34. Prepare, wake up, [look alive];
35. Take this fly-hook,
36. To pull up a fish, a *malau-tea* ;
37. This is the cold food for that kava ;
38. Pull up a piece of the best kava ;
39. Say to the young men
40. That they spread out cold food for the best kava.
41. Tell your child
42. To come this way with the cold food of the kava.
43. Bring it with the *taro* that has been warmed again,
44. With the *ulātai* which is famed.
45. Let us eat this kava.
46. Then asked Lua-le-manga,
47. Whence came this kava ?
48. It is the kava from the eastern group ;
49. That was the kava that came down from the heavens.
50. Sauā is that land towards the east ;
51. The kava [plant] was brought and distributed
52. To our Samoan group which is one.

O !

XII.—‘O GAFA O ‘AVA (1)—*A Solo.*

‘*The Pedigree of the Kava.*’

-
1. The Sā-Tangaloa held a council in the heavens ;
 2. Le-Fanonga spoke at it [when he ought not];
 3. The Sā-Tangaloa grumbled
 4. That the council’s well-known privileges were trampled on.
 5. Fanonga caused them to desire a *kava* that they knew of.
 6. [To get at it], he beat down its [thick] stem [and branches];
 7. Then he bruised the root ;
 8. He made a handle of it [to pull it up] ;
 9. He twisted it over ;
 10. He pulled it up ;

11. He dragged it along ;
12. He ran off with it ;
13. He walked off with it ;
14. Shout, shout,
15. For the kava of Longo-papa.
16. Shake, O council ground, shake,
17. For he throws it down ; it falls with a crash.
18. " There is the kava that I split up, [says Fanonga,]
19. O Sā-Tangaloa ; there is the kava ; chew it [now] ;
20. I have kept in reserve the Vai-tina."
 * * * * *
21. A joyous day, a day of delight,
22. When heavenly things were brought down from the *fale'ula*,
23. And the sacred kava chewers were paying respect to it.
 * * * * *
24. The kava that was planted by Pava
25. [Is at] Sauā-e-'ava, on the sea side of the road,
26. And at Malae-'ava on the landward side of the road.
27. The kava is spread out to dry ; the stem of the kava is yellow ;
28. The kava that was planted amongst the stones and on the rock.
29. But it is overshadowed by the leaves of the *fagafaga* tree ;
30. Its pith is white like the *sigano* blossoms.
31. O kava, the food of chiefs,
32. The kava [goes up] near to the backbone [of the island].
 * * * * *
33. O kava, many are thy plantings ;
34. [In heaps] thy burden is piled up.
35. [With] the fly-flicker and the sun-shade,
36. And my staff of office, if I attempt to stand, down I fall.
 * * * * *
37. O kava, that came down at Fale'ula,
38. Whence the three lands had their kava ;
39. Olosenga is a land of mountains ;
40. Ofu is the first to receive Upolu ;
41. Aunu'u has no standing bush to burn ;
42. There is Fui'ava and Taufi ;
43. They two planted kava by the roots of the breadfruit tree ;

44. There is the small beach of Pua'ava.
 45. The kava was taken up by Masefua,
 46. But it was chewed by Alofau ;
 47. And when you eat it, finish it off with your girdle of leaves on.
 48. Tui-tele and Lua-le-manga,
 49. You two will prepare for your journey ;
 50. Go ashore at Vini and Fanga ;
 51. Aleipata got its kava ;
 52. Fale-alili and Sanga had their kava ;
 53. Siumu and Safata had their kava ;
 54. The stem was broken and fell in the district of Noāma'a ;
 55. Tua-masanga had its kava ; [which, with]
 56. Fotu and Funé, made the three that had kava.
 57. Savai'i is a level land ; they have no kava.
 58. Thence the bird of Fuipau carried it ;
 59. The gentle trade winds blow on it ;
 60. Its bushy wings are spread out ; [be aired.
 61. [On arrival], the kava twigs were broken off and put out to
 62. From it Tonga and Fiji had their kava ;
 63. Borabora and the Tahiti group ;
 64. Rarotonga and the small islands.
 65. O kava, it is coming ;
 66. The kava of Aunu'u and Alofau ;
 67. The gentle trade winds blow on it.
 68. Let the kava start early on its voyage.
- * * * * *
69. The Sā-Tangaloa held a council in the heavens ;
 70. Le Fanonga spoke at it ;
 71. The Sā-Tangaloa grumbled
 72. That their well-known privileges were trampled on.

O !

XIII.—LE GAFA o 'AVA (2)—*A Solo.*

'The Pedigree of the Kava.'

Mr. Powell's MS. says:—"This solo and the next were given me by Aumua of Sapunaoa [in Upolu], district of Fale-alili, April 3, 1873."

1. My little bit of kava I place in Sina-sina,
 2. Where its leaves will be blown upon by the breeze.
 3. Cut a planting-stick from the *manunu* tree ;
 4. You two will dig and plough up the land ; [the twigs,
 5. [When it is grown], you will tear up the plant and break off
 6. And throw it into the house that it may be inspected ;
 7. Then cast it outside to be chewed.
 8. When diluted, let [the water] be in proper proportion.
 9. Divide it out ; let me be first.
 10. My canoe was cut in the great forest ; [trees ;
 11. There we were benighted and slept among the young timber
 12. In the valley we lifted it up [and launched it] ;
 13. My canoe goes out on a fishing voyage in the trade winds ;
 14. Pleasant art thou, O canoe ;
 15. From its moorings in the boat house,
 16. O Malietoa-faiga, unfasten Malolo-fua, the leaping canoe ;
 17. [And] carry back Tui-o-Taū on the trade winds.
 18. The lazy bird is known by the drooping of its wings.
- * * * * *
19. My little piece of kava I place in Sina-sina,
 20. Where its leaves will be blown upon by the breeze.

O !

XIV.—LE GAFA O 'AVA (3)—*A Solo.*

'The Pedigree of the Kava.'

1. O kava, the kava of Panau
2. Stands blown upon by the trade winds.
3. The kava is taken up by Mase-fua,
4. But it is chewed by Alo-fau ;
5. The Fanga-fue of Aolo'au,
6. O kava, is thy firm standing place.
7. Fanga-ima, a common man of Tafuna,
8. Brought the kava from Manu'a
9. To Laveai and Lua-le-manga.
10. Doubtless you two went early in the morning to get the kava ;

11. Your boat was beached at Aleipata.
12. [When you] spread out on the table the cold food of the kava,
13. Ascribe [to Manu'a] the honour of the growth of the kava ;
14. Aleipata got its kava from it ;
15. All Atua got its kava from it ;
16. Spread abroad the pedigree of the kava ;
17. Tua-masanga got their kava from it ;
18. A'ana got their kava from it ;
19. Spread abroad the pedigree of the kava ;
20. Manono and Olo got their kava from it ;
21. Spread abroad the pedigree of the kava ;
22. Savai'i is a level country ; it has no kava.
23. O Funé and Fotu, [stores of kava ;
24. You two contend in vain for [the honour of producing] your
25. [For it was at] Fanga-fue the kava grew up.
26. The fowl of Fuipau has its [deserved] praise ;
27. It shakes the feathers of its wings,
28. And turns to the trade winds.

O !

NOTES TO 'SOLOS' IX., X., XI., XII., XIII., XIV.

Page 96.

They have fish ; cf. 'tala ia Sā ma Mānu,' p. 74.

Worm-progeny ; cf. 'le Solo o le Va,' line 56.

Certain fishes ; cf. 'le Solo o le Va,' line 95.

Love, peace and tranquillity ; cf. 'le Solo o le Va,' lines 19, 105.

Page 97.

Sā-Tangaloa ; as usual, things on earth are, to the Polynesian, copies of the heavenly things ; for, in Sāmoa, there are many families of chiefs who bear the name of Tangaloa ; 'Sā' is a common prefix to mean 'race of,' 'family of' ; e.g., the name Sā-moa means the 'family of Moa.' The Homeric kings also are 'Dio-trephées.'

Le-Māna is the next in dignity to the supreme Tangaloa ; the Samoans believe that he can work miracles ; for here the rain comes down at his will.

The eyes of Tangaloa-a-Ui ; this semi-divine Tangaloa too can do marvellous things ; for he joins together the two severed portions of Pava's boy, and makes him whole again ; the *all searching eyes* of the god also can follow the guilty man for hundreds of miles ; and his stature exceeded that of mortals. The Egyptian Osiris is the 'many-eyed one.'

Chief in the house; thus A-Ui announces himself; he calls himself a 'chief.' The word *ali'i*, *ariki*, 'a chief,' as to its etymology, means, 'a lofty one,' one who is 'before' others.

Page 98.

The women of the household; usually young girls.

The stem of a cocoa-nut leaf; a blow from this is enough to crack a man's skull.

Mother of both spirits and men; this is referred to in another *Solo* of this series.

Made an oven; see note 8 of the 'tala' about Mafui'e.

Page 99.

They sing and are happy; fall asleep, &c.; this is said of the natives of the New Hebrides, and may be true of other islanders; certainly the Polynesians do not become quarrelsome in their cups.

Frenzy; oracle; similar experiences show themselves among the African tribes; *cf.* the effect of the intoxicating vapour on the Pythia of the Delphic Apollo; there also, as here, presents were offered by inquirers; *cf.* also Aeneid VI., 44 – 50.

Page 100.

Removing of 'tabu'; this proves that the plant had sacred uses.

Privileges of men; to drink; something analogous exists among the tribes of Australia; after the young men have passed through the 'Bora,' they have certain privileges as to food and other things.

They place the fibre in the 'kava' bowl. It has been said that the girls spit into the bowl, or spit the chewed fibre from their mouths into the bowl. Now, I have made diligent inquiry as to this, and those who know Samoa well assure me that that statement is not true, so far as the Samoans are concerned. The chewers there take the pellet from the mouth with their fingers and throw it into the bowl, which is at some distance in the middle of the circle; if the pellet rebounds from the sides of the bowl, it is regarded as well-chewed; if, being sodden with saliva, it falls flat, the *kava* is badly chewed. An old chief told Mr. Pratt, that the *kava* should be masticated so as to make the fibre loose and dry, and that they nauseate the presence of saliva in it. Attached to a chief's household, there is an *a'amaga*, a company of young men and young women, whose duty it is to chew the *kava*.

Page 101.

Highest in rank; the Samoan islanders are very ceremonious; some chiefs, belonging to families now in humble circumstances, are yet of very high rank in the *fonos*. A European, in addressing a company of chiefs, must be very careful to give to each the proper amount of respect, in act and word, which is due to him.

Circle of chiefs; *cf.* the circle of ambassadors at a European Court, when the emperor or king approaches.

That's for you; doubtless these are the inferior gods to whom not much respect is shown.

Hidden away; see No. IX., line 10.

Bird of Fuipau; while the sea currents may convey hard seeds and nuts, they would destroy the fertility of the slender *kava* roots, and so the myth requires a bird to carry the *kava* plant.

Tangaloa; cf. 'le Solo o le Va,' note 3.

Page 104.

Saua; the verb 'saua' means 'to over-spread,' 'to over-run, as with visitors.'

Page 106.

You two are come, &c.; a chief is addressed as 'you two,'—a sort of dual of majesty, for he is supposed never to be without an attendant; to ask a stranger where he comes from is no impertinence in Samoa. The whole expression here is a common form of welcome.

Ta'e-o-Tangaloa; 'ta'e' is the same word as 'kake,' *stercus*.

Heavy rain; the Samoans dislike rain, and rush off to shelter themselves even from a passing shower, much to the amusement of white men; the rain-drops, falling on their naked bodies, have a chilling effect and this, in a climate like theirs, causes discomfort.

Taro-leaf cap; 'le pulou lautalo.'

Page 107.

Head-quarters; 'tulāfale,' 'the head of a family,' 'a ruler of a village.'

La'a-mao-mao; 'a piece of rainbow'; from 'la'a' 'to step over' and *mao*, 'to be far off.' If the men of the little island of Manono see a *la'a-mao-mao*, they will not go to war.

Owl; *black heron*; this throws some light on the origin of *totemism*.

Solo IX.

Line 1. *You two*. Tangaloa thus speaks to his attendants; cf. line 8. The Polynesian dialects have *dual* forms of the pronouns.

4. *A manini*; the name of this fish is incorporated in a proverb which means 'You are reaping the fruit of your doings.'

7. *Cold food*; that is called 'fono' and is eaten with the *kava*. In the *solos*, the expression used is *se 'ava e fono a'i*, 'some *kava* to fono with.'

11—14. *Pull up*, &c.; these are all preliminary processes.

18. *Malae*; this means 'council-ground'—the open spot in or near a village, where the natives assemble for deliberation or other business; the word is often used as a part of a village name.

19. *Sāuā-e-'ava*, 'overspread with the *kava* plant.'

24. *Heavy rain*; in the text the rain is personified as 'Uao' from *ua*, 'to rain'; line 29, *rain-in-sunshine*, 'Ua-tea'; this was the wonder; there was no black rain-cloud, and yet it rained; the epithet *tea* in some Polynesian dialects means 'bright, clear'; cf. the story of *Atéa*, p. 76.

34. *Makes fun* ; 'ua fa'i atiga i tagata'; *lit.*, 'he makes *small-crumbs* of men.' In English we have a similar expression, 'he made him look *very small*.'

40. *The boys* ; this was very bad conduct in them.

43. *He struck him* ; one blow with this weapon was enough ; see above ; the *lapa-lapa*, 'the stem of a cocoa-nut leaf,' is hard, heavy, and strong.

45. *Food* ; 'fono' ; see above.

47. *And he lived* ; another version of this *solo* makes Pava first say in penitence—

Tangaloa ua fa'i tonusia ; o ita lava ia ola.

'Tangaloa has done what is right ; as for myself, let me live.'

48. The *solo* now breaks off to speak of Sina's capture ; see p. 106.

54. *Branching leaves*, *sc.*, of a fern, the 'lau-maga-maga,' the *Polypodium phymatoides*.

58. *To catch Sina* ; persons of very high rank and the sick are carried on a 'fata,' a sort of hand-chair or litter ; *cf.* our own triumphal processions.

Solo X.

Line 4. *The 'fala'* ; this fruit, when cut, somewhat resembles a piece of pine-apple ; the Samoans make a sort of bread of it.

5—7. *Fasa-fasa, faga-faga*, beautiful native trees ; the *fasa* is a 'pandanus,' the *faga* is a *ti* tree ; and the *sigano* is the blossom of the *fasa*.

9—15. Necessary preliminaries ; see *Solo IX*.

16. *Green cocoa-nut* ; the liquid of a *green*, immature, cocoa-nut is a common drink.

18. *Wild taro*, 'pula'a' ; *tava leaf*, 'lau tava.'

Solo XI.

Line 3. *One group* ; the *solos* declare that the people of all the Samoan islands are of one common origin.

5. *Borabora* is one of the Society islands.

6. *Early in the morning* ; that is, as the *kava* has such a long journey to go, it ought to start early.

10. *Thy price* ; the *solo* here asserts that Savai'i bought the *kava* from Sāuā, and the price was a brood-hen, 'tinā manafa,' (*manafa*, 'having chickens,' 'prolific').

20. *Ruling lands* ; 'lau-mua' ; there are three ruling or leading lands in Upólu.

28. *Fue and Fanga*, 'Creeping-plant' and 'Bay,' were the parents of the Pava of *Solo IX*.

30—37. The *kava* is ready, but fish must be caught to eat with it.

32. *It was evening* ; they fish by moon-light.

36. *Malau-tea* ; there is a great variety of fishes that are called *malau*, each with a descriptive adjective attached, as here ; they belong to the genera 'Myripristis' and 'Holocentrum.'

40. *Spread out* ; in preparation for a feast.

44. *Ulātai* is a salt-water shrimp.

Solo XII.

Line 1. *Council* ; 'fono' ; there Fanonga was an intruder ; see p. 113.

3. *Grumbled* ; 'talagū' ; 'gu' is the hoarse, murmuring sound of many voices.

5. *Caused a desire* ; to punish him, they made him go to fetch the 'ava *fe'ai*, 'the fierce kava.'

12—13. *Heran* ; he at first ran, dragging it at his heels ; but, ere long, from its bulk, his pace became a walk.

16. *Shake* ; the ground shakes when he throws it down in the presence of the council.

21—23. *A joyous day* ; when the *kava* was brought down from *fale'ula*, the palace of heaven, that was 'a day of delight' to men.

32—34. *Backbone* ; the *kava* grows so abundantly that the plantings of it ascend, tier upon tier, up the mountain to the very highest ridge of the island.

35. *Fly-flicker, sun-shade, staff of office*. These two lines seem to describe the effects of so great an abundance of *kava* to drink. As some Samoan Cruikshank may yet make a "Bottle" picture with these two lines from this solo as its motto ; I quote the text :—

35. O le fue-afa ma le tau-lau-ifi,

36. Ma si a'u to'o-to'o a tu, atu ua taupisi.

The *fue* was used by chiefs and orators ; cf. a similar Egyptian custom ; the *tau-lau-ifi* is a broad leaf from the *ti* tree which is worn over the eyes, as a sunshade ; the *to'o-to'o* is the orator's staff, often an heirloom.

38. *The three lands, sc.*, of Upólu ; see Solo XI., line 20.

40. *To receive Upolu* ; Upólu comes to buy, as did Savai'i in Solo XI.

41. *Bush to burn* ; the bush is burned to prepare the land for crops.

47. *Girdle of leaves on* ; the *ti* girdle ; everything must be done *ritu suo*.

49. *Prepare for your journey* ; they are to carry the *kava* plant to all these distant lands.

57. *Level land* is not so well suited for the *kava* plant.

58. *Bird of Fuipau* ; see note, page 118.

68. *Start early* ; see Solo XI., line 6.

69—72. Old ballads often wind up by quoting the lines with which they began. See also Solo XIII.

Solo XIII.

Line 6. *Inspected it* ; cf. Solo IX., line 15.

8. *Proper proportion* ; at Roman feasts too the water had to be mixed with the wine in due proportion.

10. *My canoe* ; this canoe seems to be intended for the conveyance of the *kava* plant to distant lands ; cf. Solo XI., line 6.

18. *The lazy bird*, &c.; a somewhat poetical way of saying that the work of the canoe is accomplished; or, it is a humorous hint that the poet's theme is exhausted.

Solo XIV.

Line 1—28. The substance of this *Solo* is contained in the others.

PLACE NAMES.

The following are some of the places mentioned in these *Solos* :—

A'ana, one of the divisions of Upólu.

Aleipata, the south-eastern point of Atua, which is the eastern division of the island of Upólu.

Anu'u, an island off the extreme end of Upólu.

Fale-A'ana, also called 'Fale-iva o A'ana' is a division of Upólu.

Fale-alili, an important district in the south of Upólu; it contains 2,500 people.

Fale-tolu, three divisions in Sangana of Upólu.

Fale'ula, the capital of Tua-masanga in Upólu.

Fanga, 'Bay,' is a large district in Upólu.

Fotu (*Sa-*) and *Funé* (*Sa-*) are large villages next to Mata-utu, in Savai'i.

Pava-'ai'ai, 'the true Pava,' is a village in the island of Tutuila.

Safata is in the south of Upólu in the Tua-masanga district.

Salāfai is an old name of the island Savai'i.

Sanga, a village in Fale-alili.

Sāuā, is in Taū of Manu'a.

Siumu is in the west end of Atua, the southern district of Upólu.

Tafuna was a village in Tutuila; it is now gone.

Tua-masanga is the central division of Upólu.

SOME FOLK-SONGS AND MYTHS FROM SAMOA.

Translated by the Rev. G. PRATT.

With Introductions and Notes by JOHN FRASER, LL.D.

[Read before the Royal Society of N.S. Wales, October 7, 1891.]

XV.—TANGALOA-A-UI—A 'Tala.'

How sacrifices to the Sun ceased.

INTRODUCTION—1. The Polynesians were cannibals and they offered human victims to their gods; food also and other articles of value in

daily life were presented as offerings. It is strange that, all the world over, the worship of the Sun had human sacrifices as one of its chief features. The principle that regulated the quality of the offerings in heathen worship is a simple one; for, whatever was the essential quality or feature of the god, goddess, or demon to be worshipped, so must the offering be of a similar or corresponding kind. In Rome, the goddess Ceres got her appropriate offerings of grain; Bacchus had his libations of wine; Vesta, the goddess of the hearth, had her perpetual fire; none of these could be propitiated by the blood of animals or men; but Apollo, in his character as the far-darting and pest-producing Sun, was the slayer of men; and human flesh would thus be no unwonted diet for him. The Persians gave him white horses; the priests of Baal cut their bodies with knives for him, covering themselves with gore; and in the religions of many nations, nothing of less value than the life of a human being could be laid on his altar. Another principle affecting these altar-gifts was this,—the value of the gift must be in proportion to the need of the worshipper and the importance of his request. For a god that accepted bloody sacrifices, a kid or a goat or a sheep might be sufficient in ordinary circumstances; with an extraordinary prayer, a bull; but for any dire emergency either in the family or the state, a human victim must be presented, in order to avert calamity. Hence the efficacy of such a sacrifice as that of Iphigenia when offered to a very angry or a relentless god; hence also the gift of their children to the fires of Moloch by pious mothers; hence the ‘hekatombs’ of the ancient Greeks; and everywhere, the lives of men presented by themselves or by others to turn aside some great national danger.

2. In this story, there is a fabulous account of the manner in which the Sun was led to abandon his claim to a daily supply of human flesh. The incidents are said to have happened in Atafu, which seems to me to be, not any particular island, but some myth-land of wonder where, as we learn from another tale, there are “no houses; the people sleep on the ground; the sky is their house.” This view is the more probable because, in this tale, there are four parts of the Atafu land, ‘the black,’ ‘the brown,’ ‘the fair,’ and ‘the white’; and Ui, the heroine of the tale, is the daughter of ‘Sugar-cane’ and ‘Yam.’ Seeing that the daily ‘aso’ of victims was destroying all the families in Atafu, she resolved to approach the Sun and try to get him to be satisfied with less costly food. In this, with her brother’s aid, she succeeded, as the story tells. But lest the old propensities of his solar majesty should return, she thought it prudent to leave her home; and so, at last, after some adventures she reached Manu’a, where she gave birth to a son, the great semi-divine Tangaloa-

a-Ui, and he was the father of Ta'e-o-Tangaloa, Le-Fanonga and others, who are famed in Samoan myths.

MR. POWELL'S SUMMARY—3. Ui was the daughter of a couple named Fiso and Ufi. They belonged to and lived in the Atafu land, which included Atafu'uli, Atafu mea, Atafu tea, Atafu sina. It was the custom of the people of Atafu to present a human sacrifice every day as an offering to the Sun ('ua fai le aso ole La i tagata'); each family by turns furnished a victim, either male or female. The families were thus gradually disappearing, and, in the family of Ui, there were only three survivors,—her old mother, herself, and her brother Lua-ma'a. Some say that, besides Ui, there was another daughter named Ala. The day was approaching when one of these also must be sacrificed. They wept together, each being unwilling that either of the others should die, and each contending to be the victim. Then Ui said that she would endeavour to induce the Sun to accept a substitute. Accordingly, with her brother's aid, she at once prepared her offering, which consisted of *taro*, some fish, a fowl, and portions of the *kava* plant, together with the bowl for preparing the *kava* drink, a drinking cup, a strainer, and some turmeric. These were placed carefully in a basket; and, on the morning of the day, when the sacrifice should be presented, very early before day-light, she, accompanied by her brother, repaired to the altar of sacrifice, which was on a mountain at some distance from the village and stood between two trees, a *fetanu* and a *fasa*. Shortly after she had taken her seat upon the altar, the Sun arose over the *fasa* tree. She immediately addressed him in the following strain—

Le La e, mau i mai,
E taumafa ola atu lau tagata,
Ua leai le aiga nai lou taumafa,
Le La fai atu;
Ui e, ta fia inu 'ava, &c.

Which means—

4. O Sun, approach, thy human being to eat alive;
For of this family, through thy feasting, none survive.

To this the Sun replies:

O Ui, for kava, [not for blood,] I thirst.

The virgin immediately answers:

Here's kava [grown] by a man of skill and labours many;
It stood [grew] in the rocky ground;
It stood devoted unto thee;
Its root-branches were of a rich and tempting hue;
This kava I'll divide in pieces, and with shell will scrape it well;

Will wash it ; and with the fibre-strainer rub it clean.

I'll rinse well the mouth, and chew !

In a *tava* bowl, I'll mix it ;

And strain it out to cleanse it fully from the lees.

This kava I'll now apportion !

O Sun, if thou wilt feast,

There's this fish, the '*ata'ata*, [sacred to the gods,]

The fish that near the harbour waits ;

There's this fowl, a fowl of many broods, full-grown and plump ;

Oh then ! on these now turn thy [longing] eyes ;

For of this family, through thy feasting, none survives.

The Sun approached ; he beheld a damsel well-attired, and beautiful in person. He was smitten with her beauty and loved her. From that time, the offering of human sacrifices to the Sun ceased.

5. When the Sun promised Ui that he would require no more human sacrifices, she went home with joy and reported her success. "I am not devoured, you see; the Sun said to me,—*Sau ia, o le a ola le nu'u; ua ifo le aso o le La; e le toe faia*,—'Come here; your land shall live; the offering to the Sun shall terminate; it shall not be repeated.'" Her family and the people generally rejoiced at the good news. But still her parents felt anxious and distrustful, and they said, 'Come let us leave, and go to some other land, lest the custom should be renewed, and we, as it will be our turn, become the first victims.' Accordingly, Fiso and Ufi left in a canoe, with Lua-ma'a, but Ui and Ala proceeded inland. When the sisters had come to a district called Rurutu, and to a part of it where was a boat-entrance in the reef, called Eutala, they saw on the beach two idols. These belonged to a man named Li'i, or, as others say, to two men named Nimoa'i and Lavea'i, who were sporting in the rollers. One of the idols was a trumpet shell ('*panea*, *Triton tritonis*), which was so placed on the shore that when the men shouted from the sea, the shell re-echoed the shout. Ui took up the idols and concealed them in her bag. When the owners found that the echo had ceased, they suspected the cause and gave chase to the thieves, but the theft was denied. The incensed losers uttered this imprecation on the thieves of their idols, (*o le lai ma le panae*, 'the bird and the shell'):—

Le au manumanu lē ō atu ;

Ua lā goai a'u mea ;

Au mai, a oi onatau ;

Ua lā goai au tupua ;

Nei mau matutu lava i gauta ;

A e oti i le sami.

O !

Which means—

There is a band of covetous ones going on ;
 They have stolen my things ;
 Let them bring them to me, as is proper to do ;
 [If not, let my curse be upon them ; for]
 They have stolen my images ;
 Let them never get firm footing on land,
 But let them perish at sea !

(The parents died at Rurutu.)

6. So they jumped into the sea and swam hither, [*i.e.*, to Taū in Manu'a]; and just as they arrived on the reef at the south side of Fiti-uta, at a spot still called Lua-ma'a on the south-east side of Sauā, Ui gave birth to a male child. She cast it on to the shore, between two stones, which are now named Ui and Lua-ma'a, for they two died there on the beach.

7. Tangaloa looked down from heaven, saw the child lying in that condition, took compassion on it, and sent Tuli and Fuia, his representatives, to look after it. He also sent the 'Miti' (a bird) and the 'Unga' (a kind of land crab); the Miti sucked the mucus from the child's mouth and nose, and the Unga divided the navel-string. Thus cared for and adopted by the god Tangaloa, the child was called Tangaloa-a-Ui, *i.e.*, Tangaloa the son of Ui. He grew up and took to wife Sina-a-Sa'umani. By her he had six children—(1) Ta'e-o-Tangaloa; (2) 'O Le-Fanonga; (3) 'O Lele; (4) Asi-asi-o-Langi; (5) Moe-u'u-lē-apai, (a girl), who became the wife of Tui-Fiti, 'king of Fiji.' Her brother, Ta'e-o-Tangaloa, dreamed that his sister was ill-used by her husband, Tui-Fiti, and hence he undertook the voyage celebrated in another *solo*; this he did in the canoe of Tui-Afono, 'king of Afono,' which is a village on the north side of Tutuila, between Masefau and Vatia. The sixth child of Tangaloa-a-Ui and Sina-a-Sa'umani was a girl named Sina-Tauata.

The following is the poetic account of the effort of Ui and her brother Lua-ma'a to bring to an end the offering of human sacrifices to the Sun.

[NOTE.—Mr. Pratt recently handed the original text of this *solo* to a Samoan native teacher, well acquainted with his own language, and asked him to read it. On reading it through, the 'pundit' exclaimed, "I seem to have been reading a foreign language; only the old men understand these words."—ED.]

XVI.—LE SOLO I LE LA.

1. It is [still] dark, [but] the day is dawning ;
2. The woman Ui and Lua-ma'a

3. Start on their journey before daylight,
4. And take with them a bag [containing the offering].
5. Above them were the *fetau* and the *fasa* trees ;
6. They set up there their offering.
7. Ui sat up in the *fasa* tree at Sanga.
8. Sun, Sun, stand thou forth with thy [glorious] presence.
9. Thither he flew, intending to stand on the *fasa*.

Ui speaks—

10. O Sun, come here ;
11. To eat your man alive for food.

The Sun speaks—

12. O Ui, I desire to drink kava.

Ui speaks—

13. Let me explain about the kava ;
14. This is the kava [planting] of an industrious man ;
15. It stood in a rocky place ;
16. It grew there and was reserved for a special use ;
17. The pieces of its root were scattered about ;
18. I will split up these roots of kava ;
19. And I will scrape them with the kava scraper ;
20. And strain it out with the strainer, that it may be clear ;
21. I will rinse out my mouth ; and now let me chew it.

La speaks—

22. O Ui, search the bag ;
23. Bring forth the 'fau' strainer from the bag ;
24. Strain out the kava.

Ui replies—

25. I am about to mix the kava with water,
26. But I will mix it in a 'tava'-wood bowl ;
27. I will strain it that it may be quite clear.
28. Now I will proceed to portion out the kava ;
29. Let me spread out the cold food [that goes with the kava].
30. O Sun, eat thou ;
31. There is a taro ; it is a 'maga-na'a' ;
32. There is a taro ; it is a 'fai-fai-tagata' ;
33. There is a fish ; it is an 'ata'ata' ;

34. There is a fish caught at the mouth of the reef-opening ;
35. There is a fish hatched in the rock.
36. There is a fowl, full grown and plump.
37. Let your food be changed to that ;
38. Eat the bonito of the deep.
39. But, first, let me make an explanation [to you];
40. None of our family is here for you to eat.
41. Turn thy face this way ;
42. There is none of our family in [this] thy food.
43. 'Ui, come here to me, [says La,]
44. There is a chief in thy womb.
45. When he is born, call him Tanga ;
46. [In] Atafu-uli, and Atafu-mea.'

O !

NOTES TO NOS. XV. AND XVI.

The numbers in these notes refer to the paragraphs of the 'Tala,' and the lines of the 'Solo.'

XV.

3. *Fiso* and *Ufi*; 'fiso' is 'sugar-cane,' *Saccharum floridulum*, and 'ufi' is a 'yam,' *Dioscorea*.

Atafu-uli, 'black'; *mea*, 'reddish-brown'; *tea*, 'bright, clear'; *sina*, 'white.' *Atafu*, in geography, is the Tokelau group, three hundred miles off from Samoa.

The Sun, 'La'; cognate to this word are the Melanesian words *lah* (Aneityum), 'light,' and *lumi-lumi* (Fiji), 'to shine'; *lahi* (Motu, New Guinea), 'flame,' and *na-laume* (Aneityum), 'flame.' In the Aneityumese word *lah*, the *h* (aspirate) stands for *k*, and leads us to the Samoan *lagi*, 'sky,' *lagi-mā*, 'bright heavens'; that again is connected with the New Britain word *laga*, 'clear, bright.' Cognates in the Aryan languages are Sk. *raj*, 'to shine,' *ranj*, 'to glow,' *rakta*, 'red, pure, blood' (cf. Melanesian *ra*, 'blood,') Gr. *lampas*, 'a torch,' *lampto*, 'I shine,' Lat. *luceo*, 'I shine,' &c. The Egyptian Sun-god, as is well-known, is Ra.

Aso is 'a daily offering of food to a chief.'

Lua-ma'a means 'two stones.'

Taro; the gifts here were—*magasiva*, 'the branching taro'; 'ata'ata, 'a particular kind of fish'; *tinā-manu*, 'a mother hen'; *kava*, the plant; *tanoa*, 'a kava bowl'; *ipu*, 'the kava cup'; *to*, 'the strainer'; *lega*, 'turmeric.' *Fetau* is the tree *Calophyllum inophyllum*; *fasa* is a 'pandanus' tree.

4. *Taumafa*, 'eat,' a chief's word; *taute*, 'eat,' a high chief's word.

Tava the name of a hard-wood tree.

5. *Idols*, 'tupua'; these were not idols in our sense of the word, for, although the Samoans set up images, they never worshipped them; the 'tupua' here were merely amulets, charms, fetiches, which were carried about by the owner for his protection from evil influences.

Ua lā gaoi; *lā*, 'they two,' meaning *Ui* and *Ala*.

7. *Tuli* is a Polynesian bird; cf. 'Solo o le Va,' note 2. *Fuia* is a bird, the *Sturnoides atrifusca*. *Miti* is also a bird, the *Lalage terat*. *Unga* is a 'soldier-crab.' The *Fuia* is the Maori *Huia*, and that is the tutelary bird of one of the great Maori tribes.

Sina-a-Sa'u-mani, 'Sina [the daughter] of Sa'u-mani.' Here Mr. Powell says in a note, "This is Sina-Tauata, the daughter of Sa'u-mani. There were two Sa'u-manis, namely, Sa'u-mani aitu (*aitu*, 'spirit'), a widely known man, and Sa'u-mani ali'i (*ali'i*, 'chief'). The latter was the son of Le-Fe'e-mai-lalo, 'the Octopus from below.' His wife was Si'i-si'i-mane'e; she bore Sina who became the wife of Tangaloa-a-Ui."

Fanonga means 'destruction'; *Asi-asi-o-lagi*, 'he who visits the sky'; *Lele*, 'there.'

XVI.

Line 5. *Fetau* and *fasa* are native trees; as above. The *fasa* has a bright red fruit, in appearance somewhat like the pineapple; the seeds are a brilliant red and are in much request for necklaces; girls are so fond of the red colour, that they will wear chili pods strung round the neck, even although the skin is burned thereby. The *fasa* grows in rocky places near the beach, which also is a favourite place for the *kava* plant; see *Solo* X., lines 3—5.

8. *Presence*; 'ala'ala,' a title of majesty; *lau 'ala'ala*, 'thy presence,' addressed to chiefs.

15—21. *Grew, scrape, strain, rinse*; see the *kava* solos.

19. *Kava scraper*; 'pipi-ava'; *pipi* is a 'cockle shell.'

23. *Fau*; the strainer here is made of *fau*, 'hibiscus'; elsewhere (*Solo* X., 15.) it is called the *pulu* strainer.

31. *Manga-na'a*, *manga-siva*, and *manga-lo* are different kinds of *taro*.

XVI.—MALIETOA-FEAI.

'O le tala i le fa'a-ifo o le aso o Malietoa-fe'ai.

'How the human sacrifices offered to Malietoa-the-fierce were stopped.'

—o—

INTRODUCTION—1. The story of Tangaloa-a-Ui shows that human sacrifices were offered to the gods; this story tells us that great chiefs also feasted every day on the flesh of men. What the gods do, chiefs may do also. Here, the 'aso' was stopped through the contrivance of two brothers.

MR. POWELL'S SUMMARY.—2. Tupu-ai-vao was another person to whom human sacrifices were offered, but Fua-lau of Fale-alili informs me that 'Malie-toa-the-fierce' and he were two different persons. Malie-toa lived 'far far back,' but Tupu only about ten generations ago; he daily feasted on human flesh, like the king of Fiji. The story runs thus:—

3. Malietoa-fe'ai was very oppressive; he had his man-eating day; men were brought to him as food. The people of the west had all been eaten up. A man of Sale-sa-tele, whose name was Tui, guessed that he would soon come to Fale-alili. Then he and his brother, Vaea, made a plan to put an end to his having a man-eating day.

4. There was inland a pig that came there through the marriage of their sister to Atu-u'u of Siumu. They baked the head of the pig; then they hung it up at a place where the king passed along. He looked at it, and then desired it. A council of the people was held on one of the days when the offering to the king should be made; then Tui and Vaea proposed that they should be the first to provide the feast. The king said to them two, 'Of what use is your offering; let a tray be set right below my seat, and let it be placed before me.' Then these two said to the people, 'Let the pig be prepared, and let the two lumps of lard and the liver be rubbed down together.' The chief kept on asking for the offering, but Tui said, 'Do you first eat the made-dish that is prepared.' The chief wrongly thought that it was part of the offering, but it was only the lard and liver of the pig. The king was pleased and said, 'Friend, this is the first day that I have eaten good food; but go and skin your offering of to-day.' Then they two went and Tui deliberated; the green cocoa-nut leaf was nearest to the body, but the dry cocoa-nut leaf was on the outside. He brought it and placed it before the king. He tore away the dry cocoa-nut leaf. The king looked down upon it, and the eyes of Tui shone. Then he said, 'Let this be the end of the man-eating days; let the east and the west now live, since you have found so good a substitute for human flesh.' Ever since there has been no man-eating day.

NOTES TO No. XVII.

PAR. 2. *Tupu-ai-vao* is the 'king from the bush.' *Malie-toa* is the 'agreeable cock' or warrior.

3. *Man-eating day* or *offering*; 'aso'; *q.v.*, as above, p. 127.

Fale-alili a district in the island of Upólu.

4. *Pig*; the usual present to the bride's family at a marriage.

Skin; the aborigines of Northern Queensland also skin a human body at their cannibal feasts.

King; 'tupu,' a high chief; *tray*; 'laoai.'

Made-dish; 'ofu,' native food, tied up in a leaf, ready to be cooked. The 'tupu' thought it was part of the 'aso,' and enjoyed it much.

Tui deliberated. There is a hiatus after these words; the 'tala'-maker should have told us that Tui got his brother to place him alive in the tray or basket, and to cover him up with cocoa-nut leaves so as to make the whole look like the usual 'aso'; and the brother carried this offering into the presence of the king and set it down before his seat. Then the story goes on to say that the king removed the wrappings and found Tui there, and Tui's eyes beaming upon him. This touched Malietoa with compassion as towards a friend, and he thereupon abolished human offerings.

XVIII.—MALIETOA-FE'AI.—*A Solo.*

1. You are a Fale-alili man ;
2. [So] listen to me ;
3. For our lives are about to be sung,—
4. [The story] about Fa'a-vavau and Mate-mate.
5. Tua and Lo'o were their parents ;
6. Le-tonu was their sister ;
7. She was married in Siumu to Atu-u'u ;
8. By which marriage they got a pig ;
9. They were married [and lived] in an inland village.
10. Then went Malietoa-fe'ai [thither] to wash his head. [up.
11. Some one pointed out to him, lo!, the head [of the pig] hanging
12. Let us two eat of it, [said he],
13. But there is one drawback—
14. That, if it is turned, we shall have no desire to eat of it.
15. O chief, [says Tui,] go into the house ;
16. Sit down pleasantly with them, and chat pleasantly with them,
17. While we two will take down the head and prepare it.
18. We will cook it with cocoa-nut juice poured over it ;
19. And [for it] I will pluck the leaves of the best bananas,
20. Which I will bring hither in my hands ;
21. [When] the head [is ready], I will bring it and show it to you.

Malietoa replies—

22. Friend, come gently hither ;
23. I am exhausted with hunger.
24. I will set up my staff of office—our Fale-atua ;
25. Now then, here is our Fale-atua ; leave it here ;

26. But let us have our first feast
27. On a pig that ran about at large inland.
28. Go up [inland] and get it ;
29. Take out the two lumps of lard
30. And the liver ; squeeze them out [for cooking].
31. Friend, when you have got your feast [ready],
32. Lay it out as on a tray ; lay it out
33. Close to the seat of Malietoa-fe'ai.
34. Friend, walk gently hither ;
35. I am exhausted with hunger.

Tui says—

36. O chief, do you sit still and rest,
37. Till I uncover the prepared viands ;
38. Then you will eat of them.

* * * * *

39. Malietoa ate, continued to eat
40. Well pleased, and he said,
41. 'Friend, this is the very best of feast days,
42. [For] I have eaten good food [to-day].
43. Friend, tear off the skin of the dish you two [prepared],
44. Lo ! a dry cocoa-nut leaf is on the outside,
45. And a green cocoa-nut leaf is on the inside ;
46. Tui's eyes are shining.

Malietoa says—

47. 'Friend, come now, since you have done so well,
48. Let those to the east live, let those to the west live ;
49. And if you have any number of followers, you will so arrange
50. That your feast-offering shall not become a burden.'

O !

NOTES TO No. XVIII.

Line 1. *A Fale-alili man* ; he would listen with interest to this song, for the heroes of it, Tui and Vaea, were from that district of Upólu.

3. *Our lives* ; i.e., this is an account of the way in which human sacrifices ceased there long long ago, and how 'the lives' (line 3) of the inhabitants were thus spared.

4. *Fa'a-vavau* means 'everlasting' and appears to be a by-name of the brother, Vaea, because the people's gratitude held him in everlasting

remembrance. *Mate-mate*; Mr. Powell says here, 'This *Solo* I got from Tufu o Sapunoo, who tells me that Tui was named *Mate-mate* 'the schemer,' on account of his 'quick discernment,' and Vaea was called Laoai 'tray-table,' because he placed his brother before the king in the basket or tray.

6. *Le-tonu*; 'one who is 'straight' in conduct.'

8. *Married*; *pig*; 'married' is here expressed by the word *tau*; which in Duke of York island is *taula*, 'to marry'; on a marriage the man gives a feast—a pig—to the woman's family.

10. *For a head washing*; to them a very necessary thing; they make a lather of the leaves of the *toi* tree or of wild oranges pounded up, and with this they wash their heads clean.

13. *Drawback*; the word is *pona*, 'a knot,' 'a difficulty.'

14. *Turned*; the meaning is this—when the head is first cooked, it comes out prettily browned; but if it is baked again, it will become black and so changed that it will not be desired.

15. *Go into the house*; Tui wishes him to go inside so that he may know nothing of the counterfeit arrangements for the feast which he and his brother are to make outside.

17. *We two*; i.e., the two brothers, Tui and Vaea.

18—19. *Cocoa-nut juice*; this is a favourite condiment in Samoan cooking; and the food is put in the native oven wrapped in banana leaves. The juice of a cocoa-nut seems also to have some sacred virtue in it; for it is poured on the hand that has touched a dead chief, in order to take off *tabu*. *Bananas*; two kinds are mentioned here—*fa'i*, the general name, and *mamae*.

22. *Gently*; this probably means that Malietoa's *fierceness* need not cause Tui any alarm.

24. *Staff of office*; 'to'o-to'o'; this he sets up, as a sign that offerings ('aso,' lines 26, 31, 41) must be made and thus respect shown to his rank.

26. *Feast*; 'aso,' a daily offering of food to a chief.

30. *Lard, liver*; these seem to be choice parts for a made dish.

33. *Seat*; on high occasions, chiefs sit on a chair or stool.

36. *Sit still*; 'noga,' a chief's word. Tui wants to get time to make all his preparations, unobserved.

38—39. *Eat*; 'taute,' a high chief's word.

48. *Live to the east*; i.e., no human offerings shall now be brought from east or west.

49—50. *So arrange that, when you become numerous, your offering of pigs may not be burdensome on any one family, as the offering of the human 'aso' had been found to be*; for among the islanders, certain families were devoted to the gods, and, being bound to furnish human victims, soon became extinct.

XIX.—THE KINGS OF MANU'A AND SAMOA.

—o—

INTRODUCTION :—These genealogies are partly mythical, partly historical. The account, for instance, of the progeny of Le-Fatu and Le-'ele'ele (No. XXII.) is clearly fabulous, but the list of the kings of Manu'a (No. XX.), given, as it is, by Taa-nu'u, the official recorder, is, in the main, reliable; so is also the history of the two 'Ali'a brothers (No. XIX.), for that is supported by the traditions of the Rarotongans themselves. In any case these genealogical records are worth preserving, as they show us what account the Samoans can give of their own ancestry.

Mr. Powell says, under date Dec. 10, 1870 :—Taa-nu'u, legend keeper has given me the following particulars to-day :—

The present Moa-Tui-Manu'a is the thirty-fifth of that name. Taa-nu'u himself, in his boyhood, has seen the immediately preceding Moa, who was not only Tui-Manu'a, but also priest of the gods; about fifty years ago, he was killed in a war with Fiti-uta, an inland village on Taū of Manu'a. His predecessor again was Moa-atoa, 'the complete Moa'; he lived to a great age, and in his reign there was no war. Some of the early kings also lived to a great age, but most of the more recent reigns were very short; for it was the custom to elect only men of mature age and experience to the office. The first Moa had, added to his name, the epithet '*ali'a-tama* (*tama*, 'boy' '*ali'a** 'double-canoe').

The following is the genealogy of Moa-Tui-Manu'a, 'Moa, king of Manu'a':—

There was at Le-Fagā, in the district of Fiti-uta, a band of spirits dwelling in a cave, Lua-ai-aitu, 'cave for spirits'; these gave birth alternately to men and spirits. Thus was born a man named Le-Folása, 'the prophet'; he had a son also named Le-

* This word corresponds with the Rarotongan kingly title 'Karika'; it is the same word. Sari'a, whose *malae* in Manu'a was named Rarotonga, went on a voyage in a double canoe and never returned. This is the Karika referred to in William's "Missionary Enterprises." The Rarotongans have no *s*, but, in some instances, the *k* is substituted for it; e.g., in Samoan, *sapo* is 'to catch with the hand,' in Rarotongan *kapo*; in Samoan *su* is 'wet,' in Rarotongan *ku*; hence Karika is the Samoan Sari'a.—T.P.

Folása, whose wife was Sina. By her he had a son called Le-Lologa, 'the flood,' 'the great rain.' This son had several wives, two of whom Puă, the name of a tree, and Auia-luma, 'going in front,' came to be with child at the same time ('*o le to-masaga*,' 'to be both pregnant together in the same family'). When that was known, Le-Folása prophesied that whichever of these children should be born first would have the kingdom (*ao*, 'royal title,' 'kingly dignity').

O le ā fa'aifo i le lagi Ao ;—the Ao is about to come down from the sky
 Ai se fafine e luai fanau,—on the woman who shall first bring forth;
 E taunu'u i ai Ao. —the Ao shall reach to her.

Puă gave birth to a son in the morning at Le-Fagā, but, before the child could be proclaimed king, a messenger came to call Le-Lologa to Aualuma—a place between Le-malae-o-Sao and Le-Aua-uli—where Auia-luma was in labour. So he hastened away; but, just as he arrived there, he heard the shout of the young men ('*sia-sia a taulelea*'), proclaiming the new-born child as king. Le-Lologa immediately exclaimed, 'The child of haste, not proclaimed with deliberation' ('*o le tama a le failise, ae le aoa lemu*'). Le-Lologa made light of the whole affair; he returned to Le-Fagā and reported that the kingly title had already been given ('*ua alaga le tupu, ua e'e*,' 'the king was shouted; respect was paid'). The children were therefore named 'O'Ali'a-tama, 'the younger 'Ali'a,' who was Auia-luma's child, and 'Ali'a-matua, 'the elder 'Ali'a,' Puă's child. The latter was also known as 'Le tama a le aoa lemu,' 'the child of leisurely proclamation.'

The boys grew up and used to stroll about together in the neighbourhood of Aua-luma, the younger being recognized as Tui-Manu'a and wearing the emblem of royalty, the '*lau-fau*' (*lau*, 'leaf,' *fau*, 'the hibiscus tree'),—a head band or turban of white cloth made of the inner bark of the paper mulberry. One day, when they were strolling together, they came to a cocoanut tree at a place called 'O-le-lu'u. Then 'Ali'a-matua said to his younger brother, 'By-and-by, Tui-Manu'a will not have anything to eat (*taute*, 'to eat'—a very high chief's word); for I am weak in my feet; I cannot go up the cocoa-nut tree to throw down a nut for

you ; what, if you just hang your turban on a tree and go up.' 'Very good,' said he ; and, hanging the turban on a branch, he climbed up. No sooner was he up, than the other boy seized the turban and ran to Taū, and shouted out 'O my dignity ! I have got my dignities' ('lo'u ao e, ua 'ou maua 'ou ao'). Here he remained for some time ; at last his grand-father Le-Folása sent for him. He went to Aua-luma but with much dread, and, getting there, he sat down outside the house. The Prophet called him in and told him not to fear, for things had come right according to the prediction that the first-born was to be king.

Le-Folása then ordered him to occupy the one end of the house, while 'Ali'a-tama was to occupy the other ; these were to be their seats of honour and distinction. After having stated that 'Ali'a-matua had, according to the prediction, a right to be Tui-Manu'a, since he was born before the other, he assigned to them their name and dignity ; thus :—

Ia igoa oe 'Ali'a-matua, ia Le-Afio o Moa ;

A o oe 'Ali'a-tama ia igoa oe, ia Le-Alófi o Moa.

"Be thou named Ali'a-matua, the Presence of Moa ;

And be thou named Ali'a-tama, the Circle-of-chiefs of Moa."

The former was thus declared to be king of Manu'a ; and the other to have an inferior position as chief of Fiti-uta. In case of a quarrel arising between them, neither of them was to encroach on the territory of the other, but their battle ground should be Le-Ava-tele, which is on this side of Le-Fagā. "If either of them should transgress this injunction, his land as a punishment would be overrun with creeping vines, because that would be a fight between brothers ; and he should not get the kingdom"; [*i.e.*, "A si'i atu le taua e Taū, e sauā lona lau'ele'ele e le au fue-fue ; a si'i mai le taua e Fiti-uta, e sauā lona lau'ele'ele e le au fuefue, auā 'o le tau o le uso. E le maua le malo e se nu'u si'i taua."]

Since then, there have been many wars between Taū and Fiti-uta, but the land that began the war had continual calamities.

The following explanation of the names in legends XIX.—XXII. about the kings of Manu'a may be given here :—

Tui-Manu'a, 'king of Manua.' Tui and tupu both mean a 'very high chief,' 'a king.'

Tui-Taū, 'king of Taū.'

Fiti-uta, 'Fiji-inland'; a village in the little island of Taū.

Le-fagā, 'the Bay,' in Taū.

Le-Folása, 'the prophet.'

Moa-atoa, 'the complete Moa.'

'Ali'a-tama, 'the younger 'Ali'a' (double-canoe).

'Ali'a-matua, 'the elder 'Ali'a' (double-canoe).

Lua-ai-aitu, 'cave for spirits.'

Sina, 'white.'

Le-lologa, 'the great rain.'

Auia-luma, 'going-in-front.'

To-masaga, 'both pregnant' (*masaga*, 'twins').

Puā, the name of a tree.

Auā-luma, 'the front cave'—a place.

Le-malae-o-sao, 'the *forum* of the principal chiefs.'

Auā'uli, 'the dark cave,'—a place.

Lau-fau, 'leaf of the *fau*' or 'hibiscus' tree.

O-le-Lu'u, 'shaking,'—probably a place.

Afio, 'Presence,' a little of very high dignity.

Alofi, 'Circle-of-chiefs,' a little of less dignity.

Le-ava-tele, 'the great boat-opening' in the reef.

Tufu-lē-Mata-afa, *i.e.*, Tufu of the family of Mata-afa.

Seuēa, 'a native of Wallace Island.'

Fau-tau-sala, 'punished both together.'

La-tā-nonoa, 'the bands of us two.'

Lata-soa'a, 'near mountain plantain,'—a proper name.

Futi, 'pluck out,'—name of a man or woman.

Ua-lē-galu, 'where the serf does not break,'—a place.

Tutuila, one of the islands of the Samoan group.

Tui-fe'ai, 'fierce king.'

Gautā-fusi, 'inland of the marsh,'—a place. The marsh lands for taro were generally near the shore.

Fola-le-lā, 'spreading out the sun,'—a man's name.

Tui-tele, 'great king.'

Leone, a district and bay in the island of Tutuila.

Saga-polo-tele, a chief on Upólu.

Upólu, one of the islands of the Samoan group.

Se-atu-mai-nu'u, 'one bonito from nu'u.'

Se-atu-mai-aofa, 'one bonito from aofa.'

Se-atu-mai-fea, 'one bonito from fea.'

Safáta, a district of Tua-masanga, which is the central division of Upólu, on the south side.

Vao-o-ali'i, 'the leg of the chief.'

Tagaloa-tua-lafa, 'Tangaloa-back-flat.'

A'ana-vae-ma, 'A'ana-leg-white.' A'ana is a district in Upólu.

Savai'i, a large island of the Samoan group.

Le-ulu-moega is the leading land in A'ana.

Tui-A'ana-tama-a-le-lagi, 'king-of-A'ana, son-of-the-sky.'

Vae-toe, 'leg-again.'

Tui-Toga, 'king of Tonga.'

Fa'a-sei-sei, 'cause to slide along.'

Gutu-fagu, 'mouth of a bottle.'

Sala-masina, 'cut off (punish) the moon.'

Tui-one-o-Upólu, 'king of the sand (shore) of Upólu.'

Tau-ili-ili, the name still of a district of Salea-ula in Savai'i.

Le-tua-masaga, the central division of Upólu, containing many towns and villages.

Tui-Atua, 'king of Atua,' a district in Upólu.

Mata-afa; he is commonly called Tui-Atua, king of Atua,—the eastern division of Upólu.

Tau-fau, 'continually building,'—a man's name.

Solo-solo, one of the chief villages of Atua, on a bay on the north side.

Sā-Leotā, 'family of Leota'; there are chiefs of that name.

Tupua, 'an image,' but not for worship; this is still the name of a great family in Savai'i.

Sā-Moe-gā-gogo, 'family of Moe-ga-gogo' ('bed of sea-gull'); a high chief of the Atua division in Upólu.

XX.—The following is a list of the

KINGS OF MANU'A,

as I received it to day (July 13, 1871) from Taua-nu'u.—T. P.

The name of the king.

Meaning of the name.

1. Tae-o-Tagaloa*
2. Fa'a-ea-nu'u (son of 1), "lifter up of submerged† lands."
3. Sao-io-io-manu (son of 2), "safe as the bird over there."
4. Sao-loa (son of 2), "escaping right off."
5. Le-Lologa (son of 3), "the flood."
6. 'Ali'a-matua (son of 5), "the elder 'Ali'a," or double canoe.
7. 'Ali'a-tama (son of 5), "the boy (*i.e.*, younger) 'Ali'a.
8. Fa'a-ea-nu'u } brothers as above.
9. Pui-pui-po } sons of ? "shut up by night."
10. Sili-ai-vao }
11. Ti'aligo (son of 9)
12. Se-manu (son of 10), "one bird."
13. Fa'a-toalia (son of 12)
14. Taliutafa (son of 13)
15. Ti'aligo.
16. Seuēa (daughter of 14) "a native of Uēa" (Wallace Isld.)
17. Salofi (brother of 16)
18. Taliutafa, (son of 17)
19. Tālolo-mana
20. Vao-mana (son of 19)
21. Tālolo (son of 20)
22. Tālolo-fa'a-lelei-nu'u, "Talolo who reconciles the lands."

His was a long and prosperous reign, with no wars; all the upper lands and those to the east were occupied by a large population.

Usurpers. { Poumele
 { Segi
 { Pule-tā-faga-faga; he invented a kind of double canoe.
 { Iolite

Tui-a-aitu "king of spirits."

Taalolo fana-ese "go in crowds and err in shooting."

Le-Vao, reigned from before 1830, "the bush."

* The Samoan *g* everywhere sounds *ng*. † Submerged, *i.e.*, conquered.

XXI.—THE PROGENY OF ALI'A-TAMA,

Who was the first Tui-Manu'a.

Olo-valu-tele ascended from below and became the wife of Tufu-lē-Mata'afa in Muti'e, chief of Fiti-uta. She gave birth to two girls named Seuēa and Fau-tau-sala. Seuēa became the wife of Tui-Toga; the other girl became the wife of Aua-luma and she gave birth to a girl named Lata-nonoa who became the wife of Tui-Taū, by whom he had a daughter named Lata-soa'a or Futi.

This woman, the daughter of Tui-Taū and Lata-soa'a, became the wife of 'Ali'a-tama, who was Tui-Manu'a. By her he had a daughter named Ua-lē-galu. She went to Tutuila and became the wife of Tui-E'ai of Gautā-fusi, and gave birth to a girl named Fola-le-Lā. This girl became the adopted daughter of Tui-tele of Leone. Saga-polo-tele came from Upōlu and took her to wife. [Another version bears that she became his adopted daughter; that, on one occasion, she was dressing his hair, which, according to custom in those days, was very long, and that his hair, falling on her lap, caused pregnancy]. By her he had three daughters, Se-atu-mai-nu'u, Se-atu-mai-aofa and Se-atu-mai-fe'a. The first of these became the wife of Ama, chief of Safata. By her he had a daughter, to whom was given the name of Vae-o-ali'i. She became the wife of Tagaloa-tua-lafa of Savai'i under the following circumstances:—

Tui-A'ana-vae-ma went on a visit to Savai'i. Two of his attendants were named Apé and Tutuila. This party was liberally entertained by their Savai'i hosts, and a *feti'i*, i.e., a heap of cocoa-nuts piled round a cocoa-nut tree, was placed at the king's disposal. Of these he gave Apé and Tutuila no share. This offended them, and, to be revenged, they left him and went to seek some one else as a husband for Vae-o-ali'i. So they brought Tagaloa-tua-lafa, who married her, and she became pregnant. Then they drove him away again. The son whom she bore was taken to Le-ulu-moega and named Tui-A'ana-tama-ā-le-lagi. When he was full grown, he sought as his wife Vae-toe, daughter of Tui-Toga, the offspring or

descendant of Seuēa, sister of Fa'a-tau-sala. On this errand he sent first her two female companions, Fa'a-sei-sei and Gutu-fagu. Afterwards he went himself and brought his wife Vae-toe to Upólu. By him she had two children, Sala-masina, a girl, and Tui-one-o-Upólu, a boy. This boy went to Tonga. But the girl was sought in marriage by Taū-ili-ili of Le-tua-masaga. In Sala-masina the two original branches of royalty were combined, and she was heir to the four royal titles of Tui-A'ana, Tui-Atua, Malietoa, and Na-toali-tele. Her children were Taufau and Sina, and from these two sisters most of the present chiefs' families trace their origin; from Taufau come the race of Tui-A'ana, Mata-afa, the Solo-solo chiefs, the Sā-Leotā, &c. From Sina come the race of Tupua and the Sā-Moe-gā-gogo, &c.

XXII.—THE FIRST SAMOANS.

Under date March 21, 1871, Mr. Powell says,—Tua-nu'u gave me to-day the following particulars, viz., that Le-Fatu and Le-'Ele'ele gave birth to a boy and a girl alternately, who became husband and wife. Their first two were Malae (*fem.*) and Vavau (*masc.*). These gave birth to Faimalie (*fem.*) and Faitama'i (*masc.*). Their next two were Tele (*masc.*) and Malae (*fem.*). These gave birth to Vainu'a and Tiapa, Manu and Mala, Lei, Pue and Ite.

Their immediate descendants may therefore be arranged thus:—

LE FATU MA LE-'ELE'ELE.

Malae and Vavau—	Faimalie and Faitamai—	Titi and Titi
Tele and Malae—	Valua and Tiapa—	Sava and I'i
„	Manu and Mala—	
„	Pue and Ite—	Le-Fale-tolu
Fe'ema—	Tui-Samata	
Pu-lou-lou-lele and Malae-lā—	Losi	

Another version of the progeny of Le-Fatu and Le-'Ele'ele, as given by Fofu, is this:

Faimalie and Faitama'i
 Vavau and Tele or Nu'u and Tele
 Mamao and Laveai or Ilu
 Valu'a and Tiapa.

XXIII.—SAMOAN CUSTOMS,
Analogous to those of the Israelites.

1. *Septennial observances.*

Gen. viii., 10. And he stayed yet other seven days, &c.

Deut. xv., 1. At the end of every seven years thou shalt make a release.

SEPTENNIAL OBSERVANCES OF THE SAMOANS.

1. The fire of 'Naiufi' was kept burning continuously for seven days. The 'Naiufi' was a very sacred kind of shark and so seldom seen, that, whenever one was caught, the fishermen used to keep a fire burning night and day for seven days.

2. The fire of a man who 'eats men' (a warrior) was kept burning in his honour for seven days. This was done for any one who made himself illustrious in battle.

3. The number seven was also observed in all matters that concerned the 'aitu' or minor gods. Feasts to them were often appointed seven days in advance; the order was given thus:—'Let the feast be made seven days hence.'

2. *Circumcision.*

Gen. xvii., 10. Every man child among you shall be circumcised.

Joshua v., 2. Make thee sharp knives and circumcise again the children of Israel the second time.

Samoa.—The Samoans also have circumcision for cleanliness and manliness.

3. *Bespeaking attention.*

Gen. xxiii., 6, 11, 15. Hear us, my lord.

Samoa.—The Samoans use the same form of address.

4. *The giving of names.*

Gen. xxvi., 20, 22. He called the name of the well Esek ['strife'].

Gen. xviii., 12. Therefore Sarah laughed within herself.

Gen. xxi., 3. Abraham called the name of his son Isaac.

Also Gen. xxix., 32; xxx., 24; xxxv., 18.

Samoa.—Names are given from circumstances attending birth.

Family names are hereditary. Names are given to places from events associated with them.

5. *The changing of names.*

Gen. xxviii., 19. And he called the name of that place Bethel; but the name of that city was called Luz at the first.

Samoa.—The Samoans change names for similar reasons.

6. *A feast at a marriage.*

Gen. xxix., 22. And Laban gathered together all the men of the place and made a feast.

Samoa.—The Samoans have a feast at a marriage.

7. *Presents to great men.*

Gen. xliii., 11—15. Carry down the man a present.

Samoa.—Samoans always take a present when paying a visit of respect or friendship to a superior.

8. *Benjamin's mess.*

Gen. xliii., 34. And he took and sent messes unto them from before him.

Samoa.—Samoan meals are served as here recorded.

9. *Natural eloquence.*

Gen. xliv., 18 to the end. Oh, my lord, let thy servant, I pray thee, speak a word in my lord's ears, &c.

Samoa.—A Samoan orator, or the principal man in a family, has naturally a readiness for such eloquence as this in similar circumstances. Samoan orators have a habit of giving details as here.

10. *Embalming.*

Gen. l., 2, 26. And Joseph commanded his servants the physicians to embalm his father. Also 2 Chron. xvi., 14.

Samoa.—Embalming was an ancient Samoan custom and was called 'atualala,' but is now lost. See Turner's "Nineteen Years in Polynesia."

11. *Mourning for the dead.*

Gen. l., 4, 10, 11. And when the days of his mourning were past, Joseph &c.

Samoa.—The Samoans have different stages of mourning for the dead. See Turner's "Nineteen Years in Polynesia."

12. *Doing reverence to superiors.*

Gen. l., 18. And his brethren also went and fell down before his face; and they said, Behold we be thy servants.

Samoa.—The Samoan *ifoga*, ‘bowing down, as an act of submission (from *ifo* ‘down’), is similar to this.

13. *Tatooing.*

Lev. xix., 28. Ye shall not . . . print any marks upon you.

Samoa.—The Samoans, as is well-known, tatoo their bodies.

14. *Songs of celebration.*

Num. xxi., 17. Then Israel sang this song.

Judges v., 1. Then sang Deborah . . . on that day, saying, &c.

Samoa.—The Samoans celebrate in song all important events in their experience.

15. *The invoking of a curse.*

Num. xxii., 6. Come now, therefore, I pray thee, curse me this people.

Num. xxiii., 7. Come, curse me Jacob, and defy Israel.

Samoa.—The Samoans have *o le tagata na fai tu'i*, ‘the man who devotes to destruction,’ like Balaam. They curse an object of hatred or dread, and use enchantments against it.

16. *New year offerings.*

Num. xxviii., 11–15. And, in the beginning of your months, ye shall offer a burnt offering to the Lord.

Samoa.—The principal feast of the year is that in honour of Tangaloa-fua. See “List of Months.”

17. *Wizards, enchanters, &c.*

Deut. xviii., 10, 11. There shall not be found among you . . . an enchanter, a witch, or a charmer, &c.

Samoa.—The Samoans consult persons who practise magical arts.

18. *Messengers run.*

Josh. vii., 22. So Joshua sent messengers, and they ran unto the tent.

Samoa.—Samoan messengers, sent in such a case, would do exactly the same thing. Young men, sent on a errand by the council (*fono*) of chiefs in Samoa, would set off at a run.

19. *Heads cut off in war.*

Judges vii., 25. They brought the heads of Oreb and Zeeb to Gideon on the other side Jordan. Also 2 Sam. iv., 7, 8.

Samoa.—The Samoans do the same.

20. *The use of slings and stones in war.*

Judges xx., 16. Among all this people [of war], there were seven hundred chosen men left handed; every one could sling stones at a hair-breadth and not miss.

Samoa.—The Samoans use slings and stones in war.

21. *Run-away wives.*

Judges xix., 2, 3. And her husband arose and went after her.

Samoa.—There is a great deal of this sort of thing in Samoa, and especially as in verse 3. A man goes after a fugitive wife, and the wife's family tries to keep him among themselves.

22. *Stepping over the threshold.*

1 Sam. v., 5. Therefore neither the priests of Dagon . . . tread on the threshold of Dagon; *cf.* Zeph. i. 9.

Samoa.—The Samoans step over the threshold of their houses in reverential remembrance of Tae-o-Tangaloa. See 'Tala i le Sega.'

23. *A choice portion of food for an honoured guest.*

1 Sam. ix., 22, 24. And the cook took up the shoulder . . and set it before Saul.

Samoa.—Samoans reserve a choice portion for an expected guest, a leg or a sirloin of pork, &c.

24. *Demoniacal possessions.*

1 Sam. xvi., 14, 15, 23. An evil spirit from the Lord troubled him.

Samoa.—The Samoan wizards use charms to drive evil spirits out of the bodies of those possessed by them.

25. *Single combat in war.*

1 Sam. xvii., 1–8. Choose you a man for you, and let him come down to me, &c.

Samoa.—Armies place themselves opposite to each other, a cleared space between; champions are chosen to fight for them.

26. *Familiar spirits.*

1 Sam. xxviii., 7–19. Seek me a woman that hath a familiar spirit, &c.

Samoa.—The wizards pretend that they are speaking under the influence of a spirit.

27. *Use of parables.*

2 Sam. xii., 1—4. There were two men in one city; the one rich and the other poor.

Samoa.—The Samoan traditions are often symbolical representations of real events.

28. *Relations between brothers and sisters.*

2 Sam. xiii., 10. And Amnon said unto Tamar, Bring the meat into the chamber, that I may eat of thine hand.

Samoa.—Brothers in Samoa scrupulously shun the doing of anything unseemly in the presence of their sisters, and are supposed to be above suspicion.

29. *Long hair.*

2 Sam. xiv., 26. The hair was heavy on him; *cf.* also xviii., 9.

Samoa.—Young chiefs and others wear long hair.

30. *Head officers.*

1 Kings iv., 7. And Solomon had twelve officers over all Israel.

Samoa.—The office and duties of the *tula-fale* somewhat resemble this.

31. *Funereal burnings.*

2 Chron. xvi., 14. And they made a very great burning for him. xxi., 19. And his people made no burning for him.

Jer. xxxiv., 5. But thou shalt die in peace; and with the burnings of thy fathers, &c.

Samoa.—The Samoans have burnings in honour of deceased kings and chiefs *o le lagi*; but they withhold the burnings in the case of cruel and despotic ones. *Cf.* the history of Tui Manu'a taalolo.

32. *Calling the name of the chief who is to drink.*

Jer. xxv., 17. Then I took the cup . . . and made all nations to drink.

Samoa.—It is the custom at all feasts to call out the name of the chief who is next to drink.

33. *Rod or staff of office.*

Ez. xxi., 10 *et al.* It contemneth the rod of my son.

Samoa.—The Samoan *to'o-to'o*, 'a rod or staff of office,' is a sign of authority.

NAMES OF THE SAMOAN MONTHS.¹

January—Tagaloa-fua.²

February—Fa'alele;³ Ta'afanua;⁶ Nua; Papu.

March—Tulia;⁴ a feast to that god.

April—Le-Unu;⁵ a feast to him.

May—Ta'afanua-⁶tele.

June—Malelega.⁷

July—Sina.⁸

August—Vaenao.

September—Lau-popo;⁹ a feast to him.

October—Le-Fanoga;¹⁰ a feast to him.

November—Tagaloa-ta'u;¹¹ a feast to him.

December—'Ite;¹² a feast to him.

NOTES.

1. A 'month' or 'moon' is *masina*.

2. *Fua* means 'fruit.' This is the season for great offerings to Tangaloa; all the priests were wont to assemble then, and the food which had been *tabued* for them was presented.

When they trampled on a thing made sacred, that is, when the *tabu* was violated, people were afraid and said:—'By and by a calamity will spring up, or a famine, or drought (*lit.* 'the sun'), or war,' &c.

3. '*The flying of the pigeons*;' fa'alele, 'to cause to fly.'

4. *Tulia* means 'driven,' but here '*Tulia*' is a god.

5. *Unu* is a kind of 'tree.' Le-Unu is probably one of those whom the Greeks and Romans called 'Dryads.'

6. *Ta'a*, 'to run about on'; *fanua tele*, 'the big land.'

7. *Malelega*, 'the flight of the tame pigeon.'

8. *Sina* means 'white' and is probably the moon.

9. *Lau-popo*; *lau*, 'leaf,' *popo*, 'dry'; the end of the dry season.

10. *Le-Fanoga*, 'destruction.' See the myth about him, p. 107.

11. *Ta'u* means 'renowned.'

12. '*Ite*, 'to know'; '*i'ite*, 'to predict,' hence, 'a prophet.'

NOTES ON THE USE, CONSTRUCTION, AND COST OF
SERVICE RESERVOIRS IN NEW SOUTH WALES.

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[With Plates XIV. - XIX.]

[Read before the Royal Society of N.S. Wales, October 7, 1891.]

THE Harbours and Rivers Branch of the Public Works Department having been intrusted with the design and construction of works connected with the water supply for the City of Sydney and most of the country towns in New South Wales where water has been laid on, a considerable amount of experience and information has been gained in the construction of Reservoirs of all kinds to suit various requirements ; at present this information is stored away or scattered amongst papers where it is almost inaccessible, and certainly serves no useful purpose, but when collected together in a concise form it may be of some use to members of the Engineering profession, and as a large number of Engineers are now members of the Royal Society this seems a fitting opportunity to bring the subject before them.

There are two (2) distinct classes of Reservoirs used in connection with Town Water supplies, namely, "Storage" and "Service" Reservoirs.

The former are necessarily large in extent, usually of sufficient capacity to retain at least twelve months supply of water, and may generally be looked upon as artificial lakes, the water being impounded with an earthen, masonry, or concrete dam, and stored on the natural surface. Rarely can these Reservoirs be constructed sufficiently near a city to enable them to be used for "Service" purposes.

The latter or second class of Reservoirs have to be constructed close to or within the city or town to be supplied. The special

duty of this class being to store at least one to two days supply of water close at hand and immediately available in case of a sudden demand for extinguishing fires, and to maintain an uniformity in the supply. It is to this class of Reservoir I propose to invite your attention this evening.

Where a town is supplied by gravitation from a distant Storage Reservoir it may not at first sight be apparent why a "Service" Reservoir is necessary as well, but when it is borne in mind that at least one half the whole daily consumption is used within eight hours, or, in other words, that the maximum hourly consumption of a town is more than double the average hourly consumption, it becomes clear that unless a very large gravitation main is laid, the supply will be unduly restricted when the greatest demand exists, therefore as a matter of economy alone, a Service or distributing Reservoir within the town becomes a necessity, for by its adoption, the size of the gravitation main can be reduced to a capacity sufficient to carry the maximum average daily consumption with an uniform discharge throughout the whole twenty four hours.

Again, Service Reservoirs are *almost* essential in towns supplied by pumping, and their use in this Colony has in the generality of cases to be resorted to, for out of fifteen towns where works have been carried out by the Government, it has only been possible to supply one town wholly, and one partially by gravitation.

I wish you to note that I qualified the above statement by saying "*almost* essential" as it is not absolutely necessary to construct a Service Reservoir when pumping is resorted to, many towns in other parts of the world being supplied either through stand pipes or by direct pumping into the main, but as either of these systems renders it necessary to keep the pumps constantly at work through the twenty four hours to avoid an intermittent supply, it must be at once admitted that when a Reservoir can be constructed with sufficient altitude, no reasonable cost should be spared in providing one. Modern steam pumping appliances are

however so improved, that very good results are being obtained by the direct pumping system.

I have inspected many towns in America where this method is adopted in its entirety, and in nearly all cases where it was seen at work the engines were either of the Worthington Duplex Direct Acting type, or what is known in America as the Holly system was adopted. With the Worthington type of engine, so long as the boiler pressure is uniformly maintained, the engines act automatically and keep up a steady and constant pressure in the main, but the use of engines of the Rotative Fly Wheel class is almost inadmissible, as the stored momentum will probably burst a pipe when the mains are full before the engines will be brought up unless an air vessel of very large proportions is in use, but even this is not a certain safeguard.

I am aware that very sensitive automatic gear, notably the Holly gear, has been introduced for governing such engines by the pressure in the main, but it is complicated, and I have been told by many who have had experience with it, that it is unsatisfactory, and therefore not a desirable apparatus to rely upon for "rough and ready" work such as pumping.

In towns situated on a plain such as Bourke, Wentworth, &c., the combination of the two systems, viz.—"Reservoir" and "Direct pumping" can be resorted to with great advantage. Owing to the difficulty in constructing very high tanks economically, iron tanks hereinafter described have been adopted and erected at an altitude of about seventy feet, giving a pressure of about thirty pounds (30lbs.) through the town, which is sufficient for ordinary domestic use but insufficient for fire extinguishing purposes.

Should a fire occur, the engineer only has to close the valve leading to the elevated tank and to pump direct into the main; in this case he may divert his attention from his engine, and devote it wholly to the boiler to keep up an uniform pressure. For instance, at Wentworth, where two sets of Duplex Worthington pumps have been laid down, I carried out a series of tests and

demonstrated fully what could be done in this way. The proportion between the pumps and steam cylinders in that case being such that the water pressure is just about half the boiler pressure. If the engineer desires to keep about forty-five pounds pressure in the main he must maintain ninety pounds pressure in the boiler.

When the pressure in the main rises anything over forty-five pounds through closing valves or otherwise, the engine simply stops and having no stored energy no harm results, but upon drawing off a few gallons the engine again starts to replenish what has been drawn off. In this case although the service tank only has a head of about seventy feet, in time of necessity the pressure in the main can be raised equal to that from a head of one hundred and five feet, which is sufficient for all practical purposes in country towns.

It is almost indispensable that a Service Reservoir should in all cases be lined throughout either with concrete, brick, or hammered stone pitching, for the purpose of facilitating cleansing and washing out, which, in the case of Reservoirs fed by pumping direct from rivers, must be frequently done, especially during seasons when the river may be flooded.

Were the lining omitted not only would washing out or cleansing be rendered almost impossible, but the water would be contaminated and discoloured by the wash on the muddy slopes and bottom, for it must be borne in mind that unless an unusually large Service Reservoir is constructed the water level must be rapidly altering its level every day.

In America it is usual to construct a Service Reservoir receiving water from such rivers as the Mississippi, Ohio, &c., with as large an area as possible and comparatively shallow, and thus they fill the double duty of Service Reservoir and Settling Tank. It is not an uncommon occurrence to see a deposit of as much as four feet of silt in one of these Reservoirs after a few months pumping in Spring.

The position of the Reservoir must guide the engineer as to whether it should be covered or not,—in most cases it is desirable

that a Service Reservoir should be covered in, but when it is high and sufficiently remote from the liability of contamination from dust off roads &c., covering in may be safely omitted.

When selecting the site for a Service Reservoir the engineer seldom has a wide selection of available sites to choose from, the necessary height and configuration of the surrounding country invariably points to but one or two possible sites. For convenience and economy of construction the site selected should be as nearly level as possible, although frequently, the choice must fall on a hill-side in which case one half the Reservoir may be in deep cutting, while the other half requires a retaining wall; such a site naturally points to the desirability of adopting a long and narrow rectangular Reservoir, but as a general rule the circular form will be found the most economical to adopt, unless when the land available is square and limited, under which circumstances to make the most of the land, the square form is in no wise objectionable.

Generally it will be found most advantageous to construct the Reservoir about two-thirds in excavation and one-third out, but no hard and fast rule can be laid down on this point. Much will depend upon the nature of the ground and whether "head" is an all important factor or not; in many cases "head" is of the utmost importance owing to adjacent houses being built on nearly the same level. It was this fact which led the Department to adopt the Steel Reservoirs hereinafter described, so that the water might be all stored above the surface. Spoil from the excavation should be well rammed into a substantial bank surrounding the Reservoir to back up the walls where above ground.

Of the thirty-nine Reservoirs hereinafter described, thirty-five have been constructed under the direction of the Harbours and Rivers Branch of the Public Works Department; six are rectangular, three square, and thirty are round. Twenty are built with brick walls, seven with concrete walls, and ten are constructed of iron or steel, one has dry pitched slopes, and one is cut in solid rock.

For convenience of description these thirty-nine Reservoirs may be divided into nine types, a representation of each type being shown on the plans exhibited with this paper, in most cases a section and half plan only are shown, these being considered sufficient to illustrate the general construction of the Reservoir.

Type A., Plate xiv.—Of this type two have been constructed by the Department, and one, namely the Woollahra Reservoir, by the Sydney Council; Crown Street and Paddington Reservoirs also come within this head, but particulars of cost not being available, they are not included, these have square or slightly rectangular vertical brick walls, roofed over with brick arches of about sixteen feet span, carried on cast iron girders resting on brick piers ten feet apart. The side walls being carried up, coped over, and the enclosed span filled in over the arches and spandrels with earth; this form of structure is most substantial, but is amongst the most expensive of all the types of large Reservoirs referred to. The size and cost of the three being as follows:—

No.	Dimensions.	Available capacity in gallons.	Cost per 1,000 gallons.
1	90' x 79' x 12'	501,500	£14 1s. 9d.
2	120' x 95' x 15'	1,030,000	£9 5s. 9d.
3	110' x 100' x 18'	1,000,000	£12 0s. 0d.

Type B., Plate xiv.—Circular, vertical brick walls, stopping at level of springing of arch, covered over with coke concrete annular arches fifteen to sixteen feet span. Arches carried on cast iron ring girders resting on brick piers about eight feet apart, top of arches covered over with soil, vent pipes or a valve room only being visible on top.

Of this type, three have been built, the sizes and cost being as follows:—

No.	Dimensions.	Available capacity in gallons.	Cost per 1,000 gallons.
1	100' diam. 20' deep	1,087,000	£8 17s. 9d.
2	80' 5" „ 15' „	464,000	£7 3s. 7d.
3	45' „ 14' „	134,100	£11 1s. 0d.

Type C., Plate xiv.—Circular, walls of brick, partly vertical and partly curved inwards to form a portion of the arching, remainder of covering consisting of annular coke concrete arches carried on cast iron ring girders resting upon brick piers in one case, but in all others on cast iron columns, formed of two water pipes having their spigot ends connected with a pipe collar—the lower socket end resting upon a dwarf brick pier, and upper socket fitted with a shoe to carry the girder. The pipes being filled with cement concrete—pipes used in this way are found to make a cheap and efficient pier for small Reservoirs. Top of arches covered over with soil, sloped down to meet the filling round the sides.

Of this type we have four instances, the sizes and cost are as follows :—

No.	Dimensions.	Avail. cap. in gals.	Cost per 1,000 gals.
1	130' diam. 26' deep	2,157,800	£5 9s. 4d.
2	80' „ 15' „	383,000	£8 7s. 2d.
3	65' „ 20' „	381,000	£8 19s. 1d.
4	65' „ 20' „	381,000	£8 19s. 6d.

Type C¹.—Two small underground Reservoirs have been constructed where only a small storage was necessary, they correspond nearest to Type C, but the roof is in one span, in both cases they were deep in shale or rock excavation. They were built with vertical walls, concrete floor and a brick dome roof in one span.

From the table of cost it will be seen that they are not an economical Reservoir, indeed no very small Reservoir can be, comparatively speaking economical. The sizes and cost are as follows :—

No.	Dimensions.	Avail. cap. in gals.	Cost per 1,000 gals.
1	30' diam. 20' deep	63,200	£14 13s. 0d.
2	30' „ 20' „	63,200	£14 16s. 2d.

Type D., Plate xiv.—Circular, vertical brick walls carried up in the form of a parapet wall above water level, covered over with

corrugated galvanized iron, resting upon hardwood supports. Central section of roofing a segmental arch without principals; segmental portion at sides covered with a lean-to roof resting against the parapet wall. Gutter channel formed at junction of lean-to and foot of arch.

Of this type four Reservoirs have been constructed, the sizes, capacity, and cost are as follows :—

No.	Dimensions.	Avail. cap. in gals.	Cost per 1,000 gals.
1	60' diam. 12' deep	198,200	£9 16s. 11d.
2	60' „ 15' „	246,600	£7 13s. 0d.
3	60' „ 15' „	246,600	£8 10s. 7d.
4	30' „ 12' „	49,500	£17 16s. 4d.

All the foregoing types of Reservoirs have concrete floors varying from six to twelve inches in thickness, according to the nature of the bottom, the concrete being thickened for a square of about three feet under each pier or roof support. The concrete is rendered over with a coat of cement mortar three-quarters of an inch thick, over which are laid two courses of bricks laid on their flat, flushed and grouted full in cement mortar, the upper course of brickwork being finally rendered over with a coat of cement mortar three-quarters of an inch thick. This has in all cases been found sufficient to make a thoroughly sound and water-tight bottom, in not one single instance has any leakage been observed.

The brick abutments are in all cases backed with from nine to twelve inches of cement concrete carefully laid in layers as the brickwork rises—this ensures a perfectly sound filling between brickwork and the face of the excavation, which should in all cases be taken out as carefully as possible to prevent any slips or disturbances in the surrounding formation.

In my opinion the use of puddle clay under the floor or behind the walls of a Reservoir should be studiously avoided, although this form of construction is frequently illustrated and recommended in text books. Upon examining a Reservoir that was in course of construction in this way not many years ago, I observed con-

crete being laid on a twelve or eighteen inch bed of puddle clay, which under the feet of the workmen was worked up into a nice soft condition, so much so that the concrete sank into it, and where the puddle left off and the concrete began it was hard to say, indeed the whole floor appeared to be a mixture of puddle and concrete. Water tight possibly, but not quite what was desired.

The brickwork if properly laid and grouted will be absolutely watertight, where then, comes in the necessity for puddle? If any water does soak through the brickwork and concrete backing it would be better to let it go than to attempt to retain it in the wall with puddle.

I may here mention a precaution that is necessary to take in the event of anything like a spring or soakage being found in the bottom of the excavation for a Reservoir, a dry stone French drain should be laid connecting the soakage with the outlet or scour pipe trench to let off any water, it may also be in some cases desirable to have one or two French drains leading from the outlet trench across the bottom of the Reservoir bed to let off any water that may soak from the surrounding strata down behind the abutments, as it is quite possible to get an hydraulic pressure under the floor tending to raise it up.

During the construction of one of the largest of the before mentioned Reservoirs about one hundred superficial feet of the floor was found to have lifted in a curved form about two inches at the centre to nothing round the edges; the cause, a spring underneath, was at once suspected, and upon punching a hole through the brickwork a quantity of water escaped and the floor dropped to its original level. Examination showed that the water must have found a way up through the concrete but was successfully stopped by the brickwork and rendering, but the pressure was sufficient to part the brickwork from the concrete and lift it. To effect a remedy, a groove was cut in the floor, a small pipe laid in underneath and connected with the outlet drain, this gave the spring a vent, the floor was made good again, and no further trouble was experienced.

Type E., Plate XIV.—This type includes elevated tanks on brick, iron or timber supports. They are each constructed of riveted boiler plates with a spherical bottom wholly carried from the sides. All but one of those described are roofed over with corrugated galvanized iron to keep off the direct rays of the sun.

The first two on the list are carried on eight vertical cast iron columns, sixty-five feet high and nine inches external diameter, resting on an annular ring of concrete for a foundation. The columns are suitably braced and stayed from one another, the various supply, outlet, and overflow pipes pass through the bottom vertically down to the ground, but afford no support to the tank; an expansion joint being provided in each to allow for a little movement in the bottom of the tank. Access to the interior is provided by constructing a vertical ladder passing up through a well-way three feet in diameter in the centre of the tank.

To simplify the construction, the columns in those first constructed were made vertical, but the effect is not pleasing, as the tanks have a rather top heavy appearance, but still they have been severely tested during heavy gales both empty and full, and found perfectly rigid.

When designing No. 3 inclined columns were provided with a decided improvement in the appearance, otherwise the tank is very similar to Nos. 1 and 2.

No. 4 is a tank of similar design but a little smaller, this tank is however only thirty-four feet high, and is carried on ten iron-bark timber supports well anchored down to concrete foundations. It was considered desirable to use timber supports in this case as the tank stands in a most exposed situation, immediately on top of a cliff some three hundred feet high, and it was feared that there would be a risk in using cast iron supports unless they were made very massive, and hence costly.

No. 5 tank in the list is carried on heavy brick piers connected near the upper end by arches to form a continuous support for the tank at a height of thirty feet from the ground. This is a

larger tank than those before described, but its construction is very similar, it is not however roofed in.

The dimensions and cost of these tanks are as follows :—

No.	Dimensions.	Height.	Avail. Cap. in gals.	Cost per 1000 gallons.
1	22'6 diam. 12'10 deep	65 feet	31,350	£47 11s. 1d. vert. iron column
2	22'6 „ 12'10 „	65 „	31,350	£49 4s. 4d. vert. iron column
3	22'6 „ 13'6 „	65 „	32,900	£57 18s. inclined iron column
4	20' „ 11'6 „	34 „	20,000	£48 5s. timber columns.
5	35' „ 18' „	30 „	100,000	£21 4s. brick piers, uncovered

Here the comparative economy of large tanks becomes apparent, however in comparing Nos. 1, 2, and 3 with No. 5 not only has the difference in capacity to be allowed for, but it must be borne in mind that they are erected at over twice the elevation and that they are roofed in. Another very important factor in this particular case is freight, the first three were erected at distances varying from five hundred to seven hundred and fifty miles from Sydney, this added quite fifty per cent to their cost.

In all cases when comparing the cost of various Reservoirs allowance must be made for the cost of material and labour in the locality. The prices quoted are the actual cost of the Reservoirs as constructed. Had the same work been carried out in another town where materials are cheaper or more easily obtained the cost would naturally be less. All the circumstances have to be taken into consideration before deciding whether to use brick, concrete, or iron when designing a Reservoir for any particular locality.

Type F., Plate xv.—Circular steel tanks, concrete bottom, no cover and standing on the ground. The need for storing a large body of water above the surface of the ground, and thus making the most of the available head, suggested this form of tank, and where such a need is a desideratum this type promises to be very suitable.

Plate xv., shows some of the details of construction. Four tanks of this form have been built, and being all the same as regards detail of construction, although varying in size, only one need be described. The whole of the steel used in these tanks

is of the class known as mild steel or ingot iron, with a breaking strength of not less than twenty-eight tons per square inch of original section, and an extension of at least twenty per cent. in ten inches.

Diameter of tank 100 feet, height 34 feet $2\frac{1}{4}$ inches, constructed of nine tiers of steel plates, each 14 feet $3\frac{3}{8}$ inches by 4 feet, except the top tier where the plates are 4 feet 6 inches wide; the thicknesses of the plates are as follows, two tiers of 1 inch thick, one each of $\frac{7}{8}$ ", $\frac{3}{4}$ ", $\frac{5}{8}$ ", $\frac{1}{2}$ ", $\frac{3}{8}$ ", and two of $\frac{5}{16}$ " on top. Horizontal seams: lap jointed, single riveted. Vertical seams butt jointed, with double cover plates and double riveted, all holes drilled throughout. 6" by 1" and 6" by $\frac{5}{8}$ " filling strips are riveted to the bottom plates on the outside and inside respectively between the covers to make the bottom rigid and uniform in thickness.

The bottom plate stands in a groove in a cast iron ring shoe or base plate, cast in lengths of about 7'. $1\frac{3}{8}$ " the bottom of which is 7" wide and planed all over to take a fair bearing on a concrete surface which was accurately rendered over.

Cast iron stops are embedded in the concrete and stand up about one inch, these are placed at distances of about 3'. 7" apart, their use being to keep the tank from moving off its foundation with expansion and contraction, as it is well known that iron structures such as this have a tendency to expand and contract in one direction. The bottom is formed of concrete 12 inches thick, thickened to about 1'. 9" round the edge under the shell of the tank, and on top of the concrete is laid a coat of rendering and then two courses of brick in cement mortar, the upper course being rendered over.

Many designs were prepared for ensuring a water-tight connection between the iron shell and concrete bottom, but finally the one adopted was decided upon and so far it promises to be very successful; this is shewn to a large scale on Plate xv., and may be described as follows:—

The groove in the cast iron base plate previously referred to is made 3 inches deep and $3\frac{5}{8}$ " wide; the tank shell which is $2\frac{5}{8}$ " thick

at the bottom, stands down in this groove, leaving a space outside of $\frac{3}{8}$ " wide which is caulked with rust joint cement; the inner space is $\frac{5}{8}$ " wide, into this is inserted one edge of a curved lead expansion ring made from 10lb. sheet lead, about $\frac{3}{16}$ " thick. This lead ring is curved with a radius of about $2\frac{1}{4}$ ", and well lapped and soldered at the ends. One edge is dropped into the groove and then fixed by running in molten lead which is well caulked. The other edge of the ring is flattened out and laid down against the vertical edge of the concrete base and well beaten in and then the brick floor is laid, great care being taken to bed the bricks well in mortar and set them hard in against the lead, thus providing a water-tight connection between the shell and the concrete floor. The work was in the first instance executed as above specified, but as there was always some doubt as to what pressure the lead ring would stand before it collapsed with the water pressure, care was taken, when filling the first tank made in this way, to let off the water before it was quite full and examine the ring, it was then seen that a tendency to collapse was shewing itself. Orders were then given to cut holes in the top of the ring at frequent intervals and fill it completely with sand and solder up the holes again. The tank was then filled and found to be a success. Further precautions are being taken with two of the larger tanks last completed.

A single course of bricks nine inches wide is being set on the bottom all round, end on towards the ring and standing about one and a half inch from it, the space between the brick and the ring is being filled with pure asphalte which will be soft and ductile enough to be compressed by the water pressure into any vacancy that may occur should the lead not be quite firmly set against the concrete base.

The Diagram on Plate xvii. shews the strength of this tank to resist bursting pressure, from this it will be seen that, allowing eighty per cent. of the strength of the plates for loss in the joints, the tank has a minimum factor of safety of six; the load being uniform and steady such a factor may seem unnecessary, but it is

desirable to allow a wide margin in such structures as this for "life" as attention in the way of cleaning and painting may at some period be neglected, and then the strength will be deteriorated.

A great deal of consideration has been given to this subject before determining the best method of painting or coating the interior of these steel tanks to prevent them from corrosion.

In the first instance the system of coating them with hot stockholm tar and cement was specified, this has been found to answer admirably in iron ships to protect the skin from the action of bilge water. Many large ship-builders on the Clyde and Tyne use almost nothing else. However, before applying the coating to the tanks, it was laid on plates and exposed in the S.W.S. Canal and found an absolute failure, the tar becoming quite soft and washing off. Numerous other paints and patent compositions were similarly tested, and the result was to shew that not one of the substances tried approached red lead as a protective coating. The inside of the tanks were therefore well cleaned and given two coats of red lead and oil paint, the first coat being laid on thin, and over the red lead were laid two coats of zinc white paint, the second coat being mixed with a little varnish to harden it. The outside of the tanks were given two coats of oxide of iron paint, and finished with two coats of white lead and oil paint suitably tinted.

When conducting the tests of various coating substances already referred to numerous mixtures of asphalt paint, and asphalt dissolved in spirit, were tried with only partial success, indeed any substance which is mixed with spirits or other volatile liquid is questionable, as the liquid when evaporating leaves minute passages or cells through the pigment, through which the moisture gains access to the plate, and corrosion commences.

A plan of rolling out sheets of pure asphalt about one-sixteenth of an inch thick, and about sixteen inches square, was invented and patented by Mr. T. Pridham, these sheets are applied to the

plate to be protected by first coating the plate with a solution of bitumen and kerosene, and then laying on the sheet asphalt and rolling it with a paper-hanger's roller; it adheres well, indeed it can only be removed by chipping; this system for plane surfaces appears to be almost perfect, but much trouble was experienced in getting the asphalt to adhere closely all round rivet heads, this may yet be overcome, but so far as the experiments were carried it was not satisfactory, the asphalt sagged from the underside and left a space to which water might gain admittance, and serious corrosion would go on unseen. The system is nevertheless ingenious and may yet be turned to good account.

Four tanks of the foregoing type F have been constructed, their dimensions, capacity, and cost being as follows :—

No.	Dimensions.	Avail. cap. in gals.	Cost per 1,000 gals.
1	100' dia. 33' deep	1,543,500	£3 15s. 7d.
2	100' „ 33' „	1,543,500	£3 15s. 7d.
3	100' „ 22' „	1,029,000	£4 4s. 10d.
4	75' „ 26'6" „	707,900	£4 2s. 2d.

It is clearly shown by comparing this table with previous ones that the Reservoirs are very economically designed.

Type G., Plate XVIII.—This type comprises circular, uncovered Reservoirs or tanks, with brick or concrete vertical walls and concrete floors. These are mostly constructed about two-thirds in cutting, and one-third above ground level, the upper wall being well backed up with the earth taken from the excavation. In most cases tanks of this description are used for receiving river water and allowing it to settle before pumping up to a higher level.

Eight tanks of this type have been constructed, their dimensions, capacity, and cost being as follows :—

No.	Dimensions.	Avail. Cap. in gals.	Cost per 1000 gallons—Remarks.
1	100' diam. 11' deep	502,300	£3 3s. 2d., concrete walls and floor.
2	100' „ 11' „	502,300	£3 3s. 2d., „ „
3	100' „ 11' „	502,300	£3 13s. 9d., „ „
4	100' „ 11' „	502,300	£3 13s. 9d., „ „
5	60' „ 13' „	211,700	£4 9s. 6d., brick vert. walls, con. floor.
6	56' „ 17' „	245,900	£5 0s. 11d., „ „
7	100' „ 14'6" „	750,000	£4 10s., „ „
8	140' „ 22' „	1,950,000	£3 4s. 4d., concrete vert. walls & floor

Type H., Plate XVIII.—This type includes large shallow rectangular uncovered storage or settling tanks.

No. 1 has brick walls built to a batter of one in six, and a concrete floor lined with brick. This tank is used for storing and settling river water before passing it on filter beds.

No. 2 is built of concrete walls and floor and is used as a combined settling tank and service reservoir, for this purpose it has a central brick partition, so that one half may be cleaned while the other half is in use—or one half may be filling from the pumps, while in the other half the water is settling before it is drawn off to the town.

No. 3 is built with concrete sloping walls and concrete floor; the walls, or more properly speaking the lining, is laid on the sides, which are formed to a slope of one-half to one. This class of work is satisfactory only when the tank is wholly in excavation, where any portion of the sides may be in embankment the unequal settlement is sure to cause trouble and crack the concrete lining.

Where the lining has to be raised above the natural surface, it is necessary either to construct a self supporting wall, or insert frequent buttresses.

No. 4 is constructed with side slopes of one and a half to one, covered with scabbled stone pitching, laid dry, and a concrete floor.

Where the sides are in embankment, a puddle core-wall has been constructed to make them water-tight.

No. 5 is a large service reservoir excavated almost wholly in sandstone rock. A thin floor of concrete has been laid to level the surface, and any rents or joints in the rock were well guttered out and filled with concrete. A portion of one side only had to be raised with a concrete wall above the natural rock. Taking into account the fact that there were practically no walls to construct in this case, and no roof, the reservoir does not appear to be very economical.

Of Type H, five reservoirs have been constructed, their dimensions capacity and cost being as follows:—

No.	Dimensions.	Avail. cap. in gals.	Cost per 1000 gals.
1	200' x 115' x 10' deep	985,600	£5 10s.
2	180' x 60' x 12' „	789,000	£6 15s.
3	194'6" x 194'6" x 10' „	2,235,000	£2 11s. 6d.
4	1206' x 906' x 17' „	98,500,000	19s. 1d.
5	100' x 50' x 33' „	946,396	£3 9s.

For the sake of comparison, I may describe and give the cost of one cast iron tank lately erected by the Water and Sewerage Board, and marked as Type I in the schedule of reservoirs attached to this paper.

This tank, which is constructed of cast iron plates, is twenty-seven feet square and five feet deep, with a flat bottom, and is erected at the height of twenty-four feet six inches above ground level on brick piers connected by arches on top.

No.	Dimensions.	Avail. cap. in gals.	Cost per 1000 gals.
1	27' x 27' x 5' deep	20,000	£45

The greater number of the reservoirs described in this paper were designed and carried out under the direction of Mr. E. O. Moriarty, M. Inst. C.E., late Engineer in Chief for Harbours and Rivers, and nearly the whole of them were worked out in detail, and the contract plans prepared by Mr. T. Pridham, Assoc. M. Inst. C.E., Principal Assistant Engineer for Water Supply, to whom much credit is due for the success that has been met with in carrying out so many large reservoirs without a mishap of any kind worth mentioning.

ON THE CONSTITUTION OF THE SUGAR SERIES.

By W. M. HAMLET, F.C.S., F.I.C., Government Analyst.

[*Read before the Royal Society of N.S. Wales, November 4, 1891.*]

THE structure of the sugar molecule, so long enveloped in the obscurity of an empirical formula was first investigated by Fittig and Baeyer, who, reasoning upon the well-known reducing action of dextrose compared with the similar action of aldehyde, came to the conclusion that dextrose contained either an aldehyde or ketone nucleus. That such a conclusion was the right one was afterwards proved by Kiliani in the preparation of the ammonia salt of hexahydroxyheptoic acid.

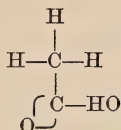
The splendid synthetic researches of Fischer and Tafel, and of Tollens with reference to the carbohydrates have placed our knowledge of the sugars upon a much higher level, the entire group may now be regarded as a definite homologous series like the alcohols and hydrocarbons. There is no further need for me to refer to these researches, the object of this paper being to apply a ring formula to the various members of the sugar family.

The value of hypothesis is nowhere better exemplified than in the famous benzene ring of Kekule of which it has been said, on the occasion of the twenty-fifth anniversary of the promulgation of Kekule's theory of the constitution of the aromatic compounds:—"This theory found the chemistry of even the immediate derivatives of benzene an almost untilled field: it has transformed it into a fertile province, to which have been annexed regions the very existence of which was unknown." The unequivocal success of this method of representing the constitution of organic compounds leads me to think it may be serviceable in the study of the sugars.

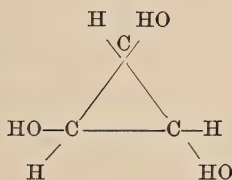
Starting with the geometrical formula for formic aldehyde we have—



which becomes the first member of the series and this may be called Monose. Acetic acid being the second in the series of fatty acids becomes the second of the new group—Biose

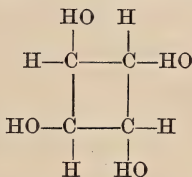


The oxidation of glycerol and subsequent treatment with phenylhydrazine by Fischer and Tafel gives us the third member, namely—Triose.



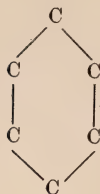
and triose may be regarded as the earliest one of the series possessing sugar-like properties.

Next is Tetrose, the only one yet prepared being Erythrose



Pentose follows with three well-known examples: these being Arabinose (present in many New South Wales plants), Xylose and Rhamnose.

By far the most important yet known is the sixth group—termed Hexose which includes many sugars known from the earliest period of the world's history, and for which I propose a ring somewhat similar to the Benzene chain, but with different linkage, thus instead of alternate double linkage there is but a single linkage throughout.



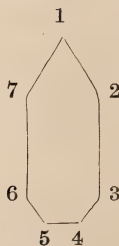
omitting the lettering we have,—



Like the Benzene ring there are three distinct positions, and these correspond to distinctive characteristics, thus may be represented both dextro-rotatory and lævo-rotatory varieties while the superposition of these might indicate the optically inactive sugars.

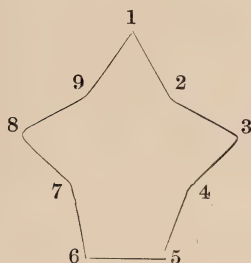
Scheibler (Berichte 18, p. 646) has already proposed the term monose for this group, the higher members being termed by him triose &c. But the synthetic researches of Fischer and Tafel show that lower members than Scheibler's monose exist, and therefore it becomes necessary to reduce the formula to its lowest limit before attempting a homologous series which I do by adopting formic aldehyde as the starting point.

The heptose chain becomes—



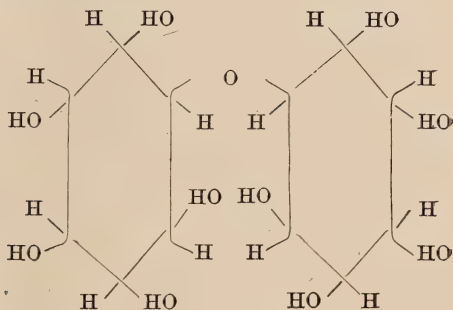
and embraces mannoheptose, glucoheptose, galaheptose, fructoheptose and rhamnoheptose.

Octose becomes an octagon in figure, while nonose the highest yet known in the sugar series is represented thus :—

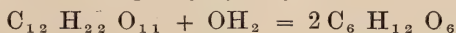


Decose is at present unknown.

Cane sugar I represent by means of two hexagons minus a molecule of water thus :—



the inversion of cane sugar by hydrolysis,—



may be regarded as complete saturation of the compound.

It remains to add that the optical isomeric hexoses may be well represented by placing the hydrogen atoms in the direction of the hands of a clock to show the dextro-rotatory position and in the reverse direction for the lævo-rotatory effect ; and equal combination of the two explaining the optically inactive sugars.

The series may be stated as follows :—

(General formula $\text{C}_n \text{H}_{2n} \text{O}_n$)

Monose ...	C	H ₂	O	Hexose ...	C ₆	H ₁₂	O ₆
Biose ...	C ₂	H ₄	O ₂	Heptose...	C ₇	H ₁₄	O ₇
Triose ...	C ₃	H ₆	O ₃	Octose ...	C ₈	H ₁₆	O ₈
Tetrose ...	C ₄	H ₈	O ₄	Nonose ...	C ₉	H ₁₈	O ₉
Pentose ..	C ₅	H ₁₀	O ₅	Decose ...	C ₁₀	H ₂₀	O ₁₀

NOTES ON THE RATE OF GROWTH OF SOME
AUSTRALIAN TREES.

By H. C. RUSSELL, B.A., C.M.G., F.R.S.

[Read before the Royal Society of N.S. Wales, December 2, 1891.]

IN older countries the rate at which various trees grow has been carefully watched for many generations, and many facts are available if one wants to know the rate of growth of particular kinds of trees. In this colony the case is very different, the available information in regard to the rate at which our indigenous trees grow is meagre. Yet it is a matter of importance in many investigations, and its bearing upon some meteorological questions has induced me to put together the few scraps of information I have available, so that they may be of use to others, and perhaps lead to the publication of additional information.

I have once or twice referred to this question in this room before, and when in February 1885, I established a Meteorological Station at Lake George, I took the precaution to measure one small tree and arrange for its measurement at intervals since. As you are aware the lake has on several occasions risen and killed trees growing on its margin, and if we could ascertain the probable age of such trees, we should have a rough measure of the intervals between these floods—a point of considerable importance; and we should be able to throw some light upon a very interesting fact mentioned by Sir Thomas Mitchell, who records that on his journey down the Murray in June 1836, he came upon a creek leading into the river, in which he saw “a single row of bare poles measuring from three to five inches in diameter,” which had evidently grown where he saw them in the centre of the stream. “The poles were the remains of Yarra trees eight or ten years old, and marked the extent doubtless of a long period of drought, which had continued until some high flood had killed them.”

The young tree that I selected in January 1885, was one of a cluster of four, close to the jetty on which the lake gauge is placed, and it was found to measure twenty-three inches round, three feet from the ground ; it was measured again on the 10th November 1891, and found to be at three feet from the ground fifty-two and a quarter inches round, almost exactly seventeen inches in diameter, that is an increase from seven to seventeen inches in diameter in six years and eight months, a rate of increase which if maintained for five years more would make it a large tree upwards of two feet in diameter and only twenty years old.

In 1875-6 the small park surrounding Sydney Observatory was planted with clumps of trees and ornamental shrubs, and amongst the trees were thirty-seven Moreton Bay Figs (*Ficus macrophylla*), on the 30th November 1891, I measured with a steel tape the circumference of nine of the largest of these trees, and found the mean circumference three feet from the ground to be four feet ten inches, the largest one measuring five feet six and a half inches.

There were forty-six trees of *Pinus insignis* planted at the same time ; the situation does not seem to suit them and they are all stunted. I measured on November 30th 1891, four of the largest and found the mean circumference three feet from the ground, two feet seven and a half inches ; the largest measured two feet eleven and a half inches.

Two Eucalyptus trees were planted at the same time on the south side of the Reserve, in trenched and manured ground. The larger of these trees, that at the south-west corner of the ground, measures three feet ten inches round three feet above the ground. It is of the *Eucalyptus globulus* variety. The other one near the cottage measures three feet five and a half inches ; they were small pot plants when put in and would now be sixteen years old. They do not seem to be growing vigorously, perhaps this is not to be wondered at as the roots cannot penetrate the solid sandstone which is close to the surface where they grow.

We have some other data which although they do not shew such a rapid growth in the trees as that just referred to yet

prove that the growth of gum trees is very rapid. In 1825-6 Sir Thomas Mitchell was engaged in a Trigonometrical survey of the colony, and for that reason cleared the tops of a number of conspicuous hills. His plan was to cut down all the trees on the hill except one selected as a land mark, hence it was, that such hills came to be called *One Tree Hills*. In 1876 I visited Mount Victoria, which was one of the hills so cleared by Sir Thomas Mitchell, and found it entirely covered by gum trees fifteen to twenty inches in diameter. The soil is poor only a slight covering to solid sandstone rocks, but the climate is good, rain often falling there, the elevation is about 3,500 feet; at the same rate of increase these trees would be two feet in diameter in sixty years, nearly three times as long as those on the margin of Lake George take to arrive at the same size.

The question whether the rate of increase is maintained as the trees grew old is a very interesting one upon which I have little or no data; of course trees situated on highlands would be affected by the seasons, but on the shore of Lake George there would always be plenty of moisture within reach of the roots, and the trees should grow steadily. The short period over which my measures have been carried on, render the results in this respect of little value, but the result may be taken for what it is worth; for the seventeen months following my first measure in 1885 the tree gained 0.31 inch in circumference each month, and for the sixty-four months following, that is from July 1886 to November 10th 1891, the tree has gained 0.39 inch in circumference each month, so that it seems to grow rather faster as it gets older.

As to the age of the tree measured at Lake George, it was growing about four and a half or five feet within the high water mark of the great flood of 1874 within which all the trees were killed, the residents when appealed to said the four trees could not be more than seven or eight years old, which agrees with probabilities as to their age, for they would not spring up until a year or two after the water retired, and it did not leave the spot they grow on until 1875, ten years before I was there. Taking

then eight years as their probable age in February 1885, they would now be almost fifteen years old, and the tree measured is now 4 feet $4\frac{1}{4}$ inches round, three feet above the ground.

The *Eucalyptus globulus* on Observatory Park is now sixteen years old and is three feet ten inches round, three feet above the ground, or six and a half inches less than the tree at Lake George which is a year younger. The trees on Mount Victoria measured about sixty-three inches round after fifty years growth, and the measures on the Lake George tree seem to justify us in assuming that it enlarged uniformly year after year.

Therefore at 15 years old the Mount Victoria tree measured 19 in.

15 ,, the Lake George tree measured *52 $\frac{1}{4}$ in.

15 ,, the Observatory Park tree measured 43 in.

The trees are all Eucalypts.

ON KAOLINITE FROM THE HAWKESBURY SANDSTONE.

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Communicated by J. H. MAIDEN, F.L.S., F.C.S.

[With Plate XXIII.]

[Read before the Royal Society of N.S. Wales, December 2, 1891.]

MESSRS. Johnson and Blake conclude their paper† in which they found the mineral Kaolinite, by suggesting the advisability of further investigations, by a study of the physical properties, and

* The probable age at this measure was 14 years $8\frac{1}{2}$ months if allowance for $3\frac{1}{2}$ months is made to bring the age up to 15 full years, it would measure 53 $\frac{3}{4}$ inches round.

† American Journ. Sci., 2nd Series, Vol. XLIII., p. 351.

by instituting fresh analyses on material *properly purified*, or shown by the microscope to be homogeneous.

They appear to recognise the difficulty in arranging, with any great success, a series of results obtained from analysing impure material; and the error in this respect has certainly not been rectified by later additions to our knowledge of the composition and formation of kaolin.

Manifestly the primary basis for a mineral species is that it is in a crystallized or crystalline condition; and it is by becoming possessed of such, that I have carried out the following investigations, with the hope of being able to assist in the elucidation of this matter.

In a paper by Mr. J. H. Collins, F.G.S., "On the Nature and Origin of Clays,"* in which he essays to arrange a new formula for Kaolinite; a number of analyses are given, these perhaps are fairly representative, but yet not free from the charge of not being properly purified, as the silica ranges from 41.6 to 49.1 per cent.

Prof. J. D. Dana in his "System of Mineralogy" has given under Kaolinite twenty-six analyses, the results of which are not concordant, the silica ranging from 43.13 to 49.1 per cent.; nor is it possible to arrange the formula given for Kaolinite ($\text{Al}_2 \text{O}_3 \cdot 2 \text{SiO}_2 + 2 \text{H}_2\text{O}$) from hardly any of these analyses.

It is not my intention to discuss the composition of ordinary clay, only so far as it is necessary for the purpose of this paper. The economic value, composition, and quantity, is a matter that can well be left for future discussion. As the clay deposits of New South Wales are extensive, and the clay often of good quality, they will ultimately be in great demand for the purpose of the potter.

Mr. Collins in his paper (*loc. cit.*) states that true kaolin, instead of being made up largely of pearly scales as stated by Dana, "is in general, and always when properly prepared, absolutely free from them. The hexagonal scales 'which may be

* Min. Mag., Vol. VII., p. 205.

detected in all [improperly prepared] kaolin,' on which Johnson and Blake, followed by Dana, founded their orthorhombic mineral Kaolinite, *do not appear to have been separated and analysed.*" The italics are mine.

I have thus taken this opportunity of investigating and analysing what I consider to be Kaolinite, and which is seen to be under the microscope, entirely composed of six sided crystals and plates which have cleaved off. Unfortunately the quantity at my disposal was small, but I have still sufficient for a good number of microscopic slides. The mineral I found in a little pocket in the sandstone at Marrickville, near Sydney, with a small quantity of coal, which coal was blocking up the entrance. Being in the solid rock with nothing like a crevice near, it was well protected from all impurities. When first found it much resembled an accumulation of minute scales of mica; it had a pearly lustre, an unctuous feel, a mealy appearance, and was of a very light cream-colour—almost white. A trace of iron was removed by dilute hydrochloric acid, but the colour of the thus treated substance was not altered in any perceptible degree.

Under the microscope it appears to be composed of six sided crystals, the basal cleavage of which is so perfect that the whole crystal appears to separate into plates. Where the plates are isolated they are perfectly transparent, and where two or three are placed one above the other, the edges of the lower are distinctly seen through the upper plates. The general appearance is represented in Plate XXIII., fig. 1.

The angles of the crystals are, as pointed out by Descloizeaux, 120° , and if the faces are extended till they meet, the resulting angle is 60° ; several plates that I measured gave these as the correct figures, or very near it.

Under the blowpipe it exfoliates and increases considerably in size. It commences to expand at once, glows with a brilliant light, and becomes intensely white. With cobalt-nitrate solution gives a fine blue colour.

Hunt (as quoted by Dana), also found that the Kaolinite from the Chaudière Falls, which was obtained from the sandstone of the Quebec Group, where it fills seams or fissures, exfoliated in white cauliflower-like shapes.

Johnson and Blake (*loc. cit.*) also state that one of the specimens they investigated, and which came from a cavity in a coal seam at Summit Hill, Carbon Co., Pa., when ignited increased in bulk, and that the microscope shows this to be the result of the exfoliation of the crystals due to the expulsion of the water.

That this is the cause, is apparent from the appearance of the crystals after heating before the blowpipe. They do not fuse, and although more rugged in appearance, the general laminated structure of the larger crystals remains fairly perfect. The one great difference is, that they have become opaque, and that individual plates are almost absent (Plate XXIII., fig. 2.)

Descloizeaux in his "Mineralogy," states that the interior structure is fibrous; the plates of my mineral do not show fibrous structure, but they show that besides the perfect basal cleavage, (which has often been pointed out), two other cleavages, one parallel to the face of the rhombic prism, the other parallel to the brachypinakoid (Plate XXIII., fig. 4). I think this is most important, (I do not find that these other cleavages have been previously noticed) and probably accounts for the manner in which kaolin is formed, as by mechanical action the crystals would readily disintegrate, breaking along these cleavage planes. That this is so appears from Mr. Collins's paper; he states that he has noticed in a large number of samples of china clay from different localities, that when the clay has been properly prepared there is an entire absence of these scaly or flaky particles, but that when the reverse is the case, that they are always present. We know that the plasticity of kaolin depends on the fineness of the material.

Completely decomposed felspar has been stated by Dr. H. C. Sorby to break up into granules of kaolin from $\frac{1}{8000}$ to $\frac{1}{80000}$ of an inch diameter. Among these granules were some small needle-

shaped crystals, and beside these, small hexagonal scales or fibrous looking aggregates of micaceous minerals.

The inference to be derived from the foregoing, is that under favourable conditions Kaolinite is first formed and that the rhombic crystals (which may be exceedingly minute) by the three cleavages break up into an extreme state of division, by mechanical action, carbon dioxide, or other agency not yet determined. We do not find a different compound when formed into clay (kaolin) than what it is when crystallized Kaolinite; it is hydrous silicate of alumina when in crystals sufficiently large to be seen, and it is hydrous silicate of alumina when these crystals are thoroughly broken up, there is no chemical replacement of any of the elements when formed into clay (kaolin), and if it was not for impurities the composition of kaolin when in the finest state of division would not differ from that of Kaolinite when perfectly crystallized.

Johnson and Blake state "that it is possible also that the plasticity of clay is related to the form of the plates of Kaolinite, perhaps to their thickness, but this is a subject that requires further investigation."

Did this mineral cleave only in one direction (the basal cleavage) the plates most probably would remain as such, and be as persistent as mica; the composition of the product undergoes no alteration as in the formation of serpentine; and as the composition remains constant no matter how fine the division, it is evident that no alteration from Kaolinite has taken place.

To see how far this theory is likely to be correct, I took some of the crystals, moistened them with a drop or two of turpentine, and ground them in a mortar, then transferred the paste direct to the slide. I found that nearly the whole of the larger crystals had disappeared, and that but a few isolated plates remained and these nearly all showing pieces broken from their edges along the cleavages that break up these plates. Had the mechanical action of the grinding been continued a short time longer I am convinced that the whole crystallized appearance would have disappeared, and that the exact resemblance of the clay from the deposits

around Sydney, when they are seen under the microscope, would have been obtained. The plates do not break up irregularly in any instance that I can discover, but always in the angular condition which these cleavages give.

This, it must be admitted is a very unnatural method ; but, I am able to show the process going on purely in a natural manner. In the coarse sandstone of the same quarry from which I obtained the Kaolinite, an almost pure white powdery looking substance is filling up the interstices around the grains of quartz. I took a portion of this and examined it under the microscope, and I found it to consist of the same identical plates and crystals ; the crystals are few in number, but it consists largely of the plates, and these plates in the majority of instances show the cleavages very distinctly, most of them having portions removed from their sides, but always broken along these characteristic cleavage planes.

I also found a beautiful example of a plate of a crystal breaking up in this manner, in the clay from Cronulla Beach, Port Hacking, near Sydney (Plate XXIII., fig. 3.), so that we have been able to trace the Kaolinite through three stages ; the crystallized, the crystallized intermediate, and the clay.

It is not to be supposed that the Kaolinite that surrounds these particles of quartz, cementing as it were the whole together, and which must be in enormous quantities, distributed over a large area, is the only material of this kind to be found in this deposit, and the matter is one worthy of further inquiry.

Whether the deposits of clay in the immediate neighbourhood of Sydney, and throughout the Hawkesbury deposits were derived originally from the decomposition of felspar is not certain ; but that the Kaolinite that forms the subject of this paper, and the clay of these deposits are somewhat identical I am convinced ; the evidence so far clearly pointing to these deposits being originally derived from the same material as surrounds the grains of sand as spoken of above. The analyses of this Kaolinite gave about .5 per cent. of magnesia, but no lime. The following three

analyses I made by direction of the Curator of the Technological Museum, upon clay from some deposits near Sydney. The first a sample from Kogarah gave .551 per cent. magnesia, and only a trace of lime ; the second, from Balmain, contained .553 per cent. of magnesia, but no lime ; the third, from Cornulla Beach, Port Hacking, gave .640 per cent. magnesia, but no lime. Specimens of these clays together with their analyses are exhibited in the Museum Collection.

An analysis is published in the Report of the Department of Mines, New South Wales, for 1890, of clay from Kogarah, this also gave .93 per cent. of magnesia but only a trace of lime. This is sufficient to show the close relationship existing between the crystallized Kaolinite and these clay deposits.

It is probable that the Hawkesbury Sandstone has been principally derived from the decomposition of granite, and the large quantity of mica existing throughout assists this supposition. The felspar contained magnesia, and most probably barium, as I have myself succeeded in discovering barytes in this formation,* which was laid down contemporaneously with the shale beds, and the sandstone. I have since traced the existence of this barytes on the opposite side of Cook's River, showing its previous existence across the valley. The presence of barium in felspar is no new thing, and even in orthoclase and oligoclase, analyses are given by Dana where barium is recorded. It would be well in taking analyses of granite from New South Wales to be on the watch for barium, it is by no means a rare mineral in this colony.

These clay deposits may eventually be proved to be kaolin, but the further consideration of this subject will require to be left for a later paper, as in the present state of our knowledge to attempt to arrive at a decision would be premature, a searching inquiry is requisite to decide the matter, as the composition cannot be decided from material evidently impure.

* Pro. Linn. Soc., N. S. Wales, Ser. 2, Vol. VI., p. 131.

The constitution of kaolin is discussed in Percy's Metallurgy (Fuel), page 93, but the arguments are principally based on the above mentioned paper by Johnson and Blake.

A figure of Kaolinite as it appears under the microscope is given in Teall's British Petrography, Plate 44, but this only shows isolated plates and scales such as may be found in ordinary clay.

The following is one analysis I made of this mineral, it was fused with the carbonates of sodium and potassium :—

·563	gram.	gave	·261	gram.	Si O ₂	
·563	„	„	·2255	„	Al ₂ O ₃	with a trace of iron.
·563	„	„	·008	„	Mg ₂ P ₂ O ₇	
·563	„	„	·0727	„	H ₂ O	
= 46·359 per cent. Si O ₂ .						40·053 per cent. Al ₂ O ₃
·512 per cent. Mg O and 12·913 per cent. H ₂ O						= 99·837.

Another analysis gave almost identical results.

The water was estimated three times, but in no instance did I succeed in obtaining 13 per cent., the highest being 12·96 per cent., the last portions are only driven off by long continued heating.

The magnesia does not appear to be an impurity, as it is a constant quantity in all the samples of kaolin yet examined ; if a portion of the water be considered basic, and the Mg O be calculated into this water the oxygen ratio is nearly 3 : 4 : 2, and the formula is as usually written Al₂ O₃ 2 Si O₂ + 2 H₂ O. The alumina was a trifle high in all three estimations that I made.

A CONTRIBUTION TO THE MICROSCOPIC STRUCTURE
OF SOME AUSTRALIAN ROCKS.

By REV. J. MILNE CURRAN, F.G.S.

[With Plates xx. - xxii.]

[Read before the Royal Society, N.S. Wales, August 5, 1891.]

CONTENTS.

- I.—Introduction.
- II.—Methods of Research.
- III.—Previous observers.
- IV.—Notable structures referred to.
- V.—Classification.
- VI.—Description of Slices.
- VII.—Conclusion.
- VIII.—Index.

INTRODUCTION.

Some five years ago, I had exceptional facilities to collect Australian Rocks from many widely separated localities. As opportunities offered, I sliced the more interesting of these samples for microscopical examination. At one time the material accumulated to some five hundred micro-slices. It would obviously be impractical to deal with this amount of material in one paper. I have therefore, selected one hundred and sixty slides for description, as a contribution to Australian Microscopic Petrography.

In making this list, I have been guided by three considerations. Firstly, I have, selected those rocks for description which I had previously studied in the field, and, therefore, with the geological relations of which I am familiar. In the second place, I am anxious to bring new matter before the Royal Society. Finally, I have given preference to those intrusive rocks that prevail on well-trying gold-fields, or are associated with any form of mineral wealth, particularly in this colony. Even within the limits, I shall be able to point to nearly every leading form of eruptive

rock, from the extreme acidic to the most basic, and from the glassy to the most perfect, holo-crystalline condition.

METHODS OF RESEARCH.

With few exceptions, I have collected my own specimens and made my own slices and micro-photographs. I use Dick and Swift's Petrological Microscope as the best form of instrument with which I am acquainted for this special work. With this microscope, the most minute crystals remain in the centre of the field, while the Nicols rotate, either crossed, inclined, or parallel under the highest powers. The change from plane to polarized light, both parallel and convergent, is easily and rapidly effected. A notice of this instrument will be found in the *Proceedings of the Royal Microscopical Society*, June 1889, p. 432, or in the *Mineralogical Magazine*, Vol. VIII., p. 160.

In dealing with basalt, a few simple micro-chemical and other tests, besides purely optical ones, are necessary. Treating the slice with hydrochloric acid is the only means, known to me of separating augite from olivine in the fine micro-granular basis (paste) of some basalts.

The determination of the proportions in which particular minerals are present in a rock can be effected in various ways. More than forty years ago, Delesse* employed a simple, but reasonably accurate method, of determining the percentage of the macroscopic minerals present in a rock. He polished a surface of the rock to be investigated, and covered it with a thin paper. The outlines of the minerals were then traced through with a pencil, and the various minerals coloured differently. The tracing was then gummed to a sheet of lead or tin-foil, and the outlines were cut round with a scissors, and the pieces of the same tint were sorted together. After removing the gum and paper, the fragments were weighed, and, in this way, the proportion of each mineral was ascertained.

* Procédé mécanique pour déterminer la composition des roches, *Annales des Mines*, 4me. sér. tome XIII. (1848), p. 373.

The more modern method is to place a thin slice under the microscope and outline the field with a camera-lucida, and then weigh the various parts of the dissected drawing upon a chemical balance.

In my own work I have adopted the method originally suggested by Dr. Sorby.* I take one or more characteristic micro-photographs and cut out the portions representing the different constituents and weigh them separately. It is often found difficult to cut out the parts exactly, so that a liberal margin must be allowed for error. I notice too, that in some of our basalts, the granular augite in the base is of a rich brownish-yellow colour. This is so non-actinic that with ordinary exposures the negative is hardly affected. The result is that in a finished print it is nearly impossible to separate the grains of augite and magnetite.† Prolonging the exposure is one way of overcoming the difficulty, but then the negative is so over exposed for feldspars and olivines that it is useless except for the one purpose of separating the two minerals just named. In these cases the use of a polarizing prism or of both nicols inclined will be found a great help when contrast is desirable in the micro-photographs.

The micro-photographs which illustrate this paper were made from the rock-slices that are submitted with it. In some instances where particular parts only of the microscopic field were required, drawings have been made from the micro-photographs.

In detecting glassy matter in rocks I have found the quartz plate of much assistance. Technically, the isotropic character of the glass should suffice for its detection, but in practice it is found much easier to catch the interference colour imparted by the quartz than to recognise a singly refracting patch.

Some idea of the nature of the glassy portions of rocks may be gained by prolonged treatment with hydrochloric acid. I have

* Petrological Notes on some North of England Dykes, J. J. H. Teall, Quart. Journ. Geol. Soc., Vol. XL., p. 216.

† It was the late Richard Daintree, C.M.G., who suggested the use of *micro-photographs* in this connection—Geol. Mag., Dec. III., Vol. v., p. 3.

often resorted to this test, and at the same time noticed the effect on any secondary products in the same slice. Basic glasses are frequently more soluble than acidic ones.*

Besides examining the rocks in thin slices, I have made notes on the appearance the rock presents as it is reduced by grinding from an opaque to a translucent chip, and finally to a transparent section. Occasionally I have separated the more magnetic minerals by an electro-magnet for separate examination.

Except using the blowpipe to test the fusibility of such rocks as basalt-glasses, the foregoing are the only methods resorted to in preparing this paper.

I have, however, largely availed myself of notes made in the field when collecting my samples. Occasionally one must deal with rocks of whose relations in the field nothing is known. The writer believes that this places any observer at a great disadvantage, and even in experienced hands is fruitful of error. The mode of occurrence of a rock in the field is a factor that should never be overlooked in microscopic study.

The macroscopic character of rocks is of much assistance in reading the microscopic structures of rock-slices. For this reason chips of all the rocks are preserved and submitted with this paper.

PREVIOUS OBSERVERS.

The following papers have references, more or less copious, to the Microscopic Structure of Australian Rocks. I found the list useful and insert it here for the convenience of my readers.

1872. Daintree, R.—Notes on the Geology of Queensland—Quart. Journ. Geol. Soc., Vol. xxviii. p. 271. This paper contains some notes by Mr. Alport on some diorites, trachytes, porphyrites and dolerites from Queensland. There are three plates showing the micro-structure of these rocks.
1875. Daintree, R.—Notes on the Microscopic Structures of certain Igneous Rocks, submitted by the Director of the Geo-

* Professor Judd and Mr. C. G. Cole on the Basalt Glasses of Western Scotland—Quart. Journ. Geol. Soc., Vol. xxxix., p. 453.

logical Survey of New Zealand—Trans. N. Zealand Inst., Vol. VII., Wellington 1875. (Read before the Wellington Phil. Soc., 8th August, 1874).

1875. Howitt, A. W.—Notes on the Microscopic Structure of some Igneous Dykes of North Gippsland—Journ. Micro. Soc. Vict., November, 1875.

1876. Howitt, A. W.—Notes on the Examination of Thin Slices of Rock under the Microscope by means of Polarized Light—Journ. Micro. Soc. Vict., November 30, 1876.

1877. Howitt, A. W.—Notes on the Geological Structure of North Gippsland. Progress Report of Geological Survey of Victoria for year 1876, Melbourne—Government Printer, 1877.

Howitt, A. W.—Notes on the Geology of Mitchell River, Gippsland—Ibid, p. 118.

1880. Howitt, A. W.—The Diorites and Granites of Swift's Creek and their Contact Zones—Proc. Roy. Soc. Vict., Vol. XVI., p. 11. (Read 12 June, 1879.)

1881. Cox, S. H.—On the Relations between Pitch Stones and Quartz Porphyries of the Mount Summer District, Canterbury—Abstract Trans. N. Zealand Inst., Vol. XIII., Wellington, 1881. (Read 4th December, 1880.)

1882. Howitt, A. W.—Notes on the Diabase Rocks of Buchan—Proc. Roy. Soc. Vict., Vol. XVIII., pp. 7 - 38. (Read 19 May, 1881.)

Liversidge, A.—On the Chemical Composition of Certain Rocks of New South Wales—Journ. Roy. Soc. N.S. Wales, Vol. XVI., p. 39.

1884. Howitt, A. W.—The Rocks of Noyang—Proc. Roy. Soc. Vict. Vol. XX., p. 19. (Read 10 May, 1883.)

1885. Howitt, A. W.—Notes on a Basalt-Vitrophyr at Tanjil—*The Victorian Naturalist*, Vol. II., No. 6, p. 67.

Howitt, A. W.—Supplementary Note on the Diabase Rocks of Buchan—Proc. Roy. Soc. Vict., Vol. XXI., p. 101. (Read 16 October, 1884.)

1886. Howitt, A. W.—The Sedimentary, Metamorphic, and Igneous Rocks of Ensay—Ibid. Vol. xxii., p. 64. (Read 12 November, 1885.)
1887. Howitt, A. W.—Notes on the area of Intrusive Rocks at Dargo—Trans. Roy. Soc. Vict., Vol. xxiii., p. 127. (Read 14th October, 1886.)
- Judd, W.—On Leucite in Australia—Min. Mag. 1887, p. 193.
- Curran, J. M.—Notes on a Leucite Basalt from Central New South Wales—Proc. Linn. Soc. N. S. Wales, Vol. ii., (Series 2nd) p. 974.
1887. Hutton, F. W.—On the so-called Gabbro of Dun Mountain—Trans. N. Zealand Inst. Vol. xix., Wellington, 1887. (Read before the Philosophical Institute of Canterbury, 4th November, 1886).
- Howitt, A. W.—Notes on the area of Intrusive Rocks at Dargo—Trans. Roy. Soc. Vict., Vol. xxiii., p. 127.
- Howitt, A. W.—Notes on the Metamorphic Rocks of the Omeo District Gippsland—Proc. Austr. Assoc. Adv. Sci., Vol. i., p. 206.
- Hutton, F. W.—On the Rocks of the Hauraki Gold-Fields—Proc. Austr. Assoc. Adv. Sci., Vol. i., p. 245.
- David, T. W. E.—Geology of the Vegetable Creek—Tin-mining Field, Sydney, 1887, p. 51.
- David, T. W. E.—Notes on some Rocks and Rock Slices, Tachylyte and Dacite, from New England—Proc. Linn. Soc., N.S. Wales, Vol. ii., Second Series, p. 1078.
1888. Hutton, F. W.—On a Hornblende-biotite Rock from Dusky Bay New Zealand—Quart. Journ. Geol. Soc., Vol. xliv., p. 745.
- David, T. W. E.—On a Variety of Intrusive Basalt from Bulli—Proc. Linn. Soc. N.S. Wales, 2 Ser. Vol. iii., p. 423, 424.
1889. Bonney, T. G.—Note on Rock collected by the Rev. W. S. Green from near the Summit of Mount Cook—Trans. N. Zealand Inst., Vol. xxi., Wellington, 1889. (Read before the Wellington Philosophical Society, 9th Jan. 1889.)
- Anderson, W.—Petrographical Notes on the Eruptive Rocks

of Mitchell near Bathurst—Rec. Geol. Survey N. S. Wales, Vol. I., p. 16.

David, T. W. E.—Notes on a collection of Igneous Rocks from Lord Howe Island—Mem. Aust. Museum, Sydney, No. 6.

David, T. W. E., and Anderson, W.—The Leucite-Basalts of New South Wales—Rec. Geol. Survey N. S. Wales, Vol. I., Part iii., p. 153.

1890. Ross, W. J. C.—The Plutonic and Metamorphic Rocks of Bathurst, New South Wales—Proc. Austr. Assoc. Adv. Sci., Vol. II., p. 420.

Hutton, F. W.—On the Granites and Associated Rocks of the Upper Buller River, New Zealand—Trans. Geol. Soc. Aust. Vol. I., p. 99, Melbourne, 1890. (Read 8th July, 1887).

Hutton, F. W.—Description of some Eruptive Rocks from the neighbourhood of Westport New Zealand—Ibid, p. 106. (Read 10th October, 1887.)

I have endeavoured to refer each rock to its natural place in the most approved system of classification. There is a decided tendency, on the part of Petrologists, to follow Professor Rosenbusch, whose splendid, and lucid works are now so accessible. Of course I follow the British as opposed to Continental Geologists, in refusing to make the age of a rock an essential character in its nomenclature. Short comings have been pointed out in every system, but the actual name matters little, after all, when we understand the sense in which it is used. There can be no confusion, for instance, when I term the holo-crystalline pyroxene rocks of Carcoar, Gabbro, provided it is clearly explained that I use that term in the sense it is employed by Professor Judd.* Even with these precautions a great deal must still be left to the individual views of each Petrologist. As Professor Bonney puts it,† “What is seen with the microscope depends not only on the instrument and the rock-section, but also upon the brain behind

* See Professor Judd's paper On the Gabbros etc. of Ireland and Scotland—Quart. Journ. Geol. Soc., Vol. XLII., p. 61.

† Anniversary Address to the Geological Society, 1885—Quart. Journ. Geol. Soc., Vol. XLI., p. 59.

the eye of the observer. Each of us looks at a section with the accumulated experience of his past study. Hence, the veteran cannot make the novice see with his eyes ; so that what carries conviction to one may make no appeal to the other."

It would be unreasonable to expect that every petrologist will agree with my reading of the facts here recorded, but as a check on error I submit my slices together with the rocks from which they were cut.

The sketch-map, which I append, will show the principal localities in New South Wales where rocks, referred to in this paper, have been collected. The presence of granite at Buccunguy, Lower Macquarie, is now recorded for the first time. Here in the heart of the great Tertiary alluvial plains, two small knolls of granite, with a flesh coloured orthoclase, are found. They are evidently the summits of hills, of considerable size, being slowly buried, as the great plains are forming.

The nature of the rocks selected from Harden, Mt. Harris, Mt. Forster, Mundoran, Rookesy, Mt. Coronga, Mt. Hope, Blayney, Cobar, and at many other places referred to, has not been hitherto studied. The rocks about Cobar are of special interest, as being associated with extensive mineral deposits. The basalts from Orange, Bathurst, Carcoar and Cargo, are notable as the result of the immense lava streams that flowed down from the craters of Mt. Canoblas. The occurrence of leucite rocks at Harden, in addition to the known localities, El. Capitan and Byerock, will prove interesting.

The diabase of Blayney, and the diabasic porphyrites of Cowra and Wellington, as well as the gabbros of Carcoar, will, I hope, add some new matter to the too scanty literature of Australian Petrography.

SOME MORE NOTABLE STRUCTURES OF THE ROCKS.

Before describing the rocks in detail, I shall deal in a general way, with some features of micro-structure, as exhibited in rocks in my collection. Taking the acidic rocks first, I have traced a very large development of felsitic rocks over New South Wales.

Around Sunny Corner, fine examples of porphyritic quartz felsites occur. The quartz can be seen from small grains, just visible to the unaided eye, up to blebs 5 mm. in diameter. The best examples occur on the hill just above the township. A well developed flow structure is often noticeable, the lines of fluxion parting around the porphyritic ingredients and meeting again.

At Cargo, there are abundant outcrops of felsitic rock. At the Ironclad Mine it is found forming the "hanging wall" of an auriferous lode. The felsite is evidently an intrusive rock. It contains porphyritic crystals and blebs of quartz. The quartzes are drawn out into long strings, as if the whole mass moved slowly in one direction under great pressure.

At the Railway Station, Carcoar, near the tunnel on the Hospital Road, and at the Glen, near the same town, compact felsites are intruded into Silurian rocks. Under the microscope a sphærolitic and sub-sphærolitic structure is apparent in many of the slices.

To the south of Dubbo, on the edges of an extensive granitic area, there are acidic rocks which must be placed under the heading of altered rhyolites. They are all flinty in character, and are of Pre-Tertiary age. They carry microscopical quartz crystals that show signs of considerable corrosion, and, in some instances, obscure traces of feldspars remain. They have all the characters of devitrified glassy rhyolites. These are the only rocks in which I have found the interesting structures known as axiolitic. The aggregations in the felsitic base are arranged in a longitudinal manner about a wavy axis.

There is a very considerable development of acidic lava flows on the Lachlan River above Cowra. They are seen to the best advantage near the junction of that river and the Rocky Bridge Creek. These rocks are associated with basic basalts in the same way as in modern volcanoes, acidic and basic materials flow from the same centres. The cavities in this lava are filled with amorphous silica and opal. The lath-shaped feldspars that form the

mass of the rock, are, in reality, *negative* crystals.* Under crossed nicols, instead of lighting up, as the slice is rotated, they remain dark in strong contrast to the devitrified base that shows colour somewhat after the manner of a felsite. This structure can only be accounted for by supposing that the silicates were profoundly altered, or removed in solution, and pseudomorphs deposited in their places. The opaline silica now filling the cavities, was probably derived in this way from the rock.

In the granites that are described further on, we have represented many interesting types of structure. Along the Queensland coast above Bowen, and about the Burdekin there is a vast area of granites varying in structure from fine-grained to porphyritic. Hornblende is a constituent, but quite subordinate to biotite in the localities I examined. The biotites show a peculiarly bent and contorted structure. A grey granite (biotite granite) forming the hills at the back of Cowra is interesting for the large number of macroscopic Carlsbad twins that the feldspars show.

There is a hornblende-biotite granite around Bathurst that alters in character as it approaches the surrounding slate country. The hornblendes get less common and finally disappear as one travels on towards the granitic boundaries. The whole structure of the rock alters along its edges. This points to the absorption of a certain amount of the sedimentary rocks in the intrusion of the granite.

The structure of the Moruya granite, on the south coast of New South Wales may be taken as typical of our best granitic rocks.† The rock is a holo-crystalline compound of orthoclase, quartz, biotite, and hornblende. The hornblende is not too plentiful. The quartz fills up the spaces between the other minerals and binds the rock into a most enduring building material.

* Professor J. W. Judd describes negative crystals formed by the action of mutual solvents in larger crystals, and the filling up of the spaces with decomposition products. See Judd on the Tertiary and Older Peridotites of Scotland—Quart. Journ. Geol. Soc., Vol. xli., p. 385.

† An analysis of the rock and note on its minerals by Prof. Liversidge, F.R.S., will be found in the Journ. Roy. Soc., N. S. Wales, Vol. xvi., p. 42.

The Australian granites could be subdivided according as they contain a preponderance of muscovite, biotite, or hornblende. But any such division would be arbitrary, as many of our granites contain two and some all three minerals in varying quantities in different parts of the same mass.

The actual structure of our granites reveals nothing new. So far as the writer is aware, no true granite has yet been met with that gives internal evidence of a metamorphic origin. That many of our granites are the result of pre-existing sediments being brought within a zone of fusion is a view which is receiving additional support each year. About Bathurst, New South Wales, for instance, highly contorted, silurian slates are found resting on granitic rocks. This granite sends veins and tongues of intrusive material into the overlying slates. The granite then is evidently not the original floor on which the sediments were deposited. At the same time no trace or vestige of this floor is anywhere to be seen. The only explanation of this, by no means uncommon relation between clastic and holo-crystalline igneous rocks is that the old floor was absorbed in the intrusion of the igneous mass. This could have happened either by the ascent of the eruptive magma or through the sediments being depressed into a zone of fusion.*

A number of our Australian granites suffer from what is called by Dolomieu "*La maladie du Granite*," and which he attributes to the action of carbonic acid issuing from a subterranean source. A microscopic examination of these granites reveals the fact that the "disease" is internal. The feldspars are found milky and opaque, with gas cavities and included matters. Cracks and cavities show as pores in the feldspars mineral, so that in reality they are permeable to water. This is the secret of the decay. In microscopic structure, we have granites ranging from porphyritic to almost felsitic structure. Many are truly porphyritic granites,

* For some very interesting matter on the origin of crystalline rocks in this way, see a paper by Dr. A. C. Lawson On the Archæan Geology of the Region north-west of Lake Superior—*Etudes sur les Schistes Cristallins*, Congrès Géologique International, 4me Session, Londres, 1888.

while others, as those of Young, Nymagee, north of Armidale, and Araluen are pseudo-porphyrific, that is, large crystals are developed in an already coarsely crystalline mass.

Amongst the basalts we have many interesting varieties of structure to record. At Bathurst, there is a long line of hills capped with basalt that flowed down from Swatchfield.* In macroscopic structure it resembles many well known basalts of the Old World. It is prismatic in the field, and under the microscope micro-porphyrific in structure with idiomorphic augites and olivines. The micro-slices of this rock show beautiful examples of a streaming structure of the feldspars.

Another basalt extensively developed further west about Orange Carcoar, and Cargo, is of an entirely different microscopic structure. Here we have the feldspars forming the only idiomorphic constituents, with the olivines and glassy matter wedged in between. Still further west, in the same colony, there is yet another type of basalt. It is found in many localities about Dubbo but chiefly to the east of that town in a huge stream running north and south. In this rock the olivines are all altered to various secondary minerals. The macroscopic structure ranges from the average basalt to a dolerite, and when the olivine has completely changed, the rock might be called a diabasic dolerite.

On the northern slopes of the Canoblas, there is an interesting porphyritic basalt. The ground-mass or paste is an exceedingly fine micro-crystalline aggregate, chiefly of plagioclase, magnetite and unindividualized glassy matter. In this are set porphyritic crystals of oligoclase.

Basalts showing a decided ophitic structure are represented from Dubbo, and from many of the New England basaltic plateaux. Fluidal movements, while in a molten condition, are indicated in a great number of the slices by the arrangement of the feldspars, and by the presence of fractured crystals. It is very noteworthy that in the feldspars of all our Australian Tertiary eruptive rocks,

* Wilkinson, Ann. Rept. Dept. Mines N.S. Wales for 1878, [1879.], p. 238.

the lath-shaped crystals are seldom complete at their ends. They branch and have step-like terminations, but perfect sections are rare. On the contrary, the more basic minerals as olivine and augite are commonly idiomorphic.

The slices of the basic rocks show examples of the structures referred to by Rosenbusch under the headings of hyalopilitic, pilo-taxitic, hypo-crystalline-porphyrific, vitro-porphyrific, and holocrystalline-porphyrific.*

In the order of consolidation our basalts generally follow the law of decreasing basicity, and in this respect correspond with similar rocks from other parts of the globe. A possible exception may exist in cases where it will be pointed out that in certain eruptive rocks the felspar has preceded the augite, while in others the augite has preceded the felspar. Instances of this kind are of particular interest in view of the attention which the subject is receiving at this time. I may state that the commonly accepted views on the subject are clearly summarised by Mr. J. J. Harris Teal in a lecture delivered in the Woodwardian Museum, Cambridge.† Professor J. W. Judd points out that other influences, besides an increasing acidic magma, may determine the order of solidification, particularly as interpreted by enclosures of one mineral in another.‡ Those who consider, he remarks, the successive crops of crystals formed in a rock, as being determined by the alteration in the composition of the residual magma by the constant separation of the basic minerals from it, will find it difficult to harmonize such views with the facts presented to us at Krakatoa. The rocks of Krakatoa strongly suggest, that the minerals crystallized out of a magma, and the residuum of mixed silicates can be separated to a greater or lesser extent and *then recombined in fresh proportions.*

* Rosenbusch, Mikroskopische Physiographie der Massigen Gesteine, Second Edition, pp. 726–728.

† Nature, March 12th, 1885, p. 447.

‡ The Lavas of Krakatoa, by Professor J. W. Judd—Geol. Mag. Dec. III., Vol. v., pp. 8–9.

A wide field for observation, particularly in microscopic work, is opened up by these suggestions. As far as it can be made out the order of solidification of the various minerals in the eruptive rocks is studied in the descriptive part of this paper.

Among the basic rocks included in the slices dealt with are some examples of those interesting forms known as tachylytes or basalt-vitrophys. A splendid example of these glassy rocks occurs as a selvage along a joint in basalt near Pratt's Residence Blayney Carcoar Road, New South Wales. In structure, the rock is macroscopically sphærolitic, and of a rich blue-black colour. The sphærolites are of a nut-brown colour and radial in character, and around them are clear absorption spaces.

In a sphærolitic tachylyte, from Vegetable Creek, New England the sphærolites stand out as warty prominences of a black and dark brown colour on the weathered rock. Films of a decomposed material on the surface of the rock are of a bright blue colour, giving it a very remarkable appearance. Crowds of these sphærolites render the rock opaque in places, even in the thinnest slices.

In the diorites and diabases too we have to deal with some interesting structures, though perhaps not new to petrologists.

There is a well-marked diabase rock at Blayney, New South Wales. Microporphyritic crystals of augite are developed in a light-coloured paste of the same mineral with felspar. The absence of well-defined plagioclase will perhaps justify the retention of the term "diabase" for this rock. Some ten miles farther south there is another development of a plagioclase augitic rock, but in this instance, there is an entire absence of a paste between the crystals. It is therefore perfectly holo-crystalline, and, for reasons which are explained further on, I retain the name, gabbro, for this rock.

The microscopic examination of a number of our dyke-rocks reveals the fact that true hornblendic diorites are not at all so common as is generally supposed. A number of rocks that have passed as diorites are clearly made out to be compounds essentially

of plagioclase and a monoclinic pyroxene. It was supposed, at one time, that hornblende characterised ancient rocks, and that the presence of augite could be relied on as distinguishing rocks of a more recent date. "It may be admitted that this distinction is a real one, but its significance and value are greatly diminished when we remember the relations which exist between the two minerals in question. Hornblende and augite are interesting examples of a dimorphous substance; in chemical composition they are identical, or rather they are liable to variations between the same limits, but in their crystalline forms and optical characters they differ from one another. It has been proved that hornblende is the stable, and augite the unstable condition of the substance in question. If hornblende be fused and allowed to cool it crystallises in the form of augite. On the other hand, augite-crystals in rocks of ancient date are found undergoing gradual change and passing into hornblende."*

As far as I have been able to observe in this colony the presence of hornblende, rather than augite in an eruptive rock is no indication of its age. Neither have I so far been able to point to an undoubted change from a rhombic pyroxene to a mineral optically monoclinic, nor even of an augite to a hornblende. These interesting alterations have been noted both in American and European rocks, and will no doubt be observed in Australian rocks as the study of petrology becomes popularised.†

CLASSIFICATION OF THE ROCKS.

As a matter of convenience it will be well to group the rocks dealt with. I shall therefore take the material after this scheme.

Eruptive Rocks.

Acidic.	{	Holocrystalline.	{	Granite.
			{	Hornblende-biotite granite.
	{	Micro-crystalline, or Crystalline with a paste	{	Biotite granite.
			{	Quartz porphyry.
			{	Felspar porphyry.
			{	Quartz felsite.

* *Volcanos*, by J. W. Judd, F.R.S., 1881, p. 267.

† Williams, *Gabbros of Baltimore*—*Bulletin of U. S. Geol. Survey*, No. 28, p. 47.

Intermediate.	{	Holocrystalline	{	Diorites.
		Crystalline with a paste	{	Diabase.
			{	Augite porphyrite.
			{	Diabase porphyrite.
Basic.	{	Glassy.	{	Tachylyte.
		Crystalline whole or in part.	{	Basalt vitrophyr.
			{	Basalt including plagioclase basalt, leucite basalt, olivine basalt.
		Holocrystalline.	Gabbro.	

The slides of sedimentary and metamorphic rocks are so few in number that it is quite unnecessary to classify them. The above classification, it will be understood, is merely intended as a convenient grouping of the rocks referred to in this paper.

DESCRIPTION OF THE SLICES.

It may be well to define a few structural terms, after Rosenbusch, as they are in constant use in studying the slices.

An authigenic mineral is one that came into existence with, or after the rock containing it.

An allogenic mineral is one that is of more ancient origin than the rock containing it.

Minerals bounded by crystallographic contours, being allowed free growth during consolidation, are termed idiomorphic.

Minerals that have been hindered in their crystallographic development, and whose boundaries therefore are determined by the contours of surrounding minerals are said to be allotriomorphic.

- Sometimes a mineral which at one time possessed crystallographic form, owes its present irregular and fretted outline to the action of the molten magma in which it floated, prior to solidification. Such a mineral is said to be corroded.

The structure in which allotriomorphic masses of augite are penetrated by idiomorphic crystals of felspar is known as ophitic.

Intersertal structure is characterised by the presence of a hypo-crystalline interstitial substance wedged in between the felspars.

The term *pilotaxitic* is applied to a *holo-crystalline* structure, especially characteristic of certain *porphyrites* and *basalts* in which the ground-mass consists essentially of slender laths and microlites of felspar in felted aggregation. The lath-shaped felspars often exhibit a streaming fluxion-structure.

The addition of films of glass to a *pilotaxitic* rock produces a *hyalopilitic* structure.

Dolerite, basalt, and anamesite are terms of pre-microscopic days, and may be of occasional use still. The modern petrographers generally follow Professor Rosenbusch and refer the basalts to one or other of these structural varieties:—1. *hypidiomorphic granular*, 2. *intersertal*, 3. *holo-crystalline-porphyrific*, 4. *hypo-crystalline*, and *vitropyric*.*

Slice 1.—Portion of a lava flow; Tumberumba, New South Wales. A grey to black rock, showing greenish crystals of olivine; breaks with a conchoidal fracture. Under the microscope it shows an ophitic structure, prisms of felspar penetrating the pyroxene in a perfect manner. The rock is microscopically *holo-crystalline* approaching to a *pilotaxitic* structure. In plane light pyroxenes show a rich brownish-red. The felspars are colourless and the magnetite, of course, black and opaque. In shape the magnetite is seen to occur as cubical grains, long prism-like forms, and also in aggregations. The largest magnetites measure about the one-hundredth part of an inch. There is a considerable amount of green colouring matter following the cracks and lining a few cavities in the slice. This colouring matter has its origin in the decomposition of the olivines as can easily be understood by an inspection of the slice. In polarized light, with crossed nicols, the rock has a particularly rich and bright appearance, interstitial matter not being too abundant. The felspars show no disposition towards a flow structure; on the contrary they present the appearance of a felted aggregate. The minerals in this slice are, *plagio-*

* Rosenbusch, *Mikroskopische Physiographie der Massigen Gesteine*, Second Edition, pp. 723 - 729.

clase, augite, olivine and magnetite. Some of the large olivines show an interesting example of the process of alteration of olivine to serpentine. The green serpentine has filled up cracks and eaten its way a little on either side. The serpentine is then seen sending out spear-shaped points into the undecomposed substance.

Slice 2.—Basalt, Star Lead, Gulgong. This basalt varies from a pilotaxitic to a hyalopilitic, but the glassy matter is neither commonly seen nor great in quantity. The rock is wholly crystalline, there being present no interstitial matter. Under the microscope, the rock is remarkable in structure for the rather peculiar way in which the magnetite is wedged in between the other minerals. This rock differs from most basalts in the absence of anything approaching porphyritic crystals of olivine or augite. The augite is, for the most part, in grains also wedged in between the feldspars. A great deal of the magnetite appears to be of secondary origin, as it shapes itself around the plagioclase crystals, while on the contrary, some true cubes of this mineral are found included in the feldspars. As in the rock, just described, magnetite sometimes runs in irregular strings to a considerable distance in the rock. The average length of the lath-shaped feldspars may be put down as the one-hundredth part of an inch. The small patches of glass are rendered almost opaque by the presence of granular magnetite. There is no streaming of the feldspars noticed around large crystals, but the majority of the feldspars point in one direction which may be taken as evidence of a flow structure.

Slice 3.—Tertiary Basalt, Star Lead, Gulgong, New South Wales. Macroscopically this rock is of a bluish-grey colour. It has a general appearance of having undergone considerable alteration without approaching to anything that might be called decomposition. There is nothing sparkling that catches the eye, as in basalts generally, and when struck with the hammer the ring is rather dead. Aggregations rather than porphyritic crystals of a dark green mineral are barely recognisable. Under the microscope in plane light, the peculiar disposition of the magnetite is the first thing to attract one's notice. This mineral

is often seen in the slice moulded perfectly round the felspars, and, in one instance, a cruciform felspar is completely enveloped in the opaque magnetite. It is not at all likely in the original separation of the minerals from a molten magma that the more basic mineral should be the last to crystallize. Magnetite was, without doubt, the first to separate and these anomalies must be explained by assuming that a certain quantity of the magnetite is of secondary origin. The largest felspars measure the one-fiftieth of an inch, their average size being about one-seventieth of an inch. There is very little olivine in the slice and when recognised under crossed nicols, it is always seen in allotriomorphic granules. The pyroxene is of a greenish-yellow shade in ordinary light. To distinguish it from the olivine recourse must be had to crossed nicols under which the olivines are seen to stand out in clear prismatic colours.

Slice 4.—Basalt, Tingha, New South Wales. This rock forms portion of a Tertiary basaltic flow. On freshly broken surfaces it shows a sparkling blue-black appearance. A few micro-porphyrific minerals are just visible to the unaided eye. Under the microscope the rock is seen to consist mainly of plagioclase and augite with rods and patches of magnetite. These minerals form a micro-crystalline ground-mass in which are set micro-porphyrific crystals of fairly fresh olivine. No isotropic matter can be detected. The rock is coloured a light green in places through secondary minerals. Rods of magnetite are very noticeable in this slice and many of them measure one-seventieth of an inch in length. In polarized light, olivine is found to occur as granules in the base. No porphyritic crystals of augite occur, but this mineral fills up spaces in the ground-mass, both as granules and short prisms.

Slice 5.—Tertiary Basalt, Tingha, New South Wales. Only one of the constituents (olivine) of this rock is visible to the unaided eye in the slice. Magnetite is abundant, and is seen moulded around the ends of the felspars as in the last slice. The magnetite is also often seen in perfect wedges filling up the angles

between two plagioclases. The feldspars are well knitted or felted over the field, and show no sign of streaming in any direction. The ends of the laths branch and break off in "match-wood fashion" and are seldom complete. The olivine is largely micro-porphyrific containing much magnetite. With crossed nicols, the composite character of many of the feldspars is at once apparent. The structure is intersertal and pilo-taxitic. The order of consolidation appears to have been—1. magnetite, 2. augite and olivine, 3. feldspars. Some of the layers of olivine are of a previous consolidation and some of the magnetite is a secondary product.

Slice 6.—Basalt, Glen Innes, New England. In hand specimens this basalt is a dark blue-black compact rock of very fine crystalline structure. Cavities, probably caused by steam while the rock was in a pasty condition, are seen in every sample. The rock is sound and shows few signs of decomposition. It forms part of one of the great Tertiary lava flows so well known in the northern districts of this Colony. Under the microscope, the mass of the slice is hypocrystalline-porphyrific, the ingredients being augite, devitrified glass and olivine. The feldspars show signs of corrosion, one very good example of which is seen in this slice. The larger olivines are disposed to form groups with a similar optical orientation. Generally the olivines are allotriomorphic and well preserved. The magnetite is not so abundant as in the Tingha basalt. It occurs in grains well distributed throughout the slice and forms neither rods nor wedges. There is no approach to an ophitic structure.

Slice 7.—Basalt, Glen Innes. In general structure this slice is very similar to the preceding one. There is more clear glassy matter present, and the olivines are all allotriomorphic. A few of the last named minerals are represented by complete pseudomorphs.

Slice 8.—Porphyritic Basalt, German's Hill, Mt. Canoblas, New South Wales. This is probably an older basalt than the normal basalt that flowed down the Canoblas towards Orange on one side,

and Carcoar, Forest Reefs, and Cudal on the other. These specimens were taken from the Orange-Cargo Road on the highest shoulder of the mountain which the road traverses. In hand specimens the rock is of a dark colour showing grey to brown on weathered surfaces. It is thickly set with glistening crystals of a felspar, many of which show repeated twining in reflected light. Under the microscope, in plane light, the large crystals are seen spread through an exceedingly fine-grained intersertally composed base. The lath-shaped felspars in this base measure on an average the one-thousandth part of an inch up to the one-fivehundredth in length. The character of this base is very uniform in all the slides. Under high powers some isotropic or partly devitrified granules are seen, together with some irregular grains of magnetite. The porphyritic felspars all clearly of allogenetic origin. Some of these felspars are broken and others greatly corroded by the liquid magma. On this slide one remarkable large twin is seen with three of its sides sharp and idiomorphic, while the fourth shows every sign of being corroded and eaten into by the surrounding magma to a considerable extent. On the edge of the slice two good examples of broken porphyritic oligoclase can be observed. The oligoclase is, in some instances, beautifully zoned. A line of inclusion marks certain zones within the crystals showing a former outline. The building up of the crystal was stayed in its growth at this point, and a subsequent growth produced the outer part. When these crystals are examined with crossed nicols, it will be noticed that just as the point of extinction, for the central core, has been passed, a dark outer zone of extinction makes its appearance, gradually extinguishing as the centre lightens. A very fine example will be found on the edge of this slice next to the numbered label. There is one other remarkable plagioclase on this slide. In plane light, the outlines are noticed to be idiomorphic and the crystal seems filled, towards the centre, with portions of the base. Besides the base matter there is also included a large olivine and a larger augite. In the centre, the main plagioclase is represented by plates of its own material, distributed like a

broken tessellated pavement. These plates are quite separate one from the other, and yet, under crossed nicols, they all *extinguish together*. It is evidently a crystal that has been corroded through, or one hindered in its complete development by taking up too great an amount of unsolidified magma. The latter I believe is the true explanation of this remarkable structure. There is also in this slice a twin plagioclase near a porphyritic augite on that part of the slice next the numbered label, that extinguishes on either side of the composition plane at angles of 33° and 34° nearly. The crystal is therefore cut close to the zone $OP : \infty P \infty$, and the mean angle would point to the felspar being oligoclase.

Slice 9.—Porphyritic Basalt, German's Hill, Mount Canoblas, New South Wales. The same exceedingly fine base characterizes this slide. Under a one-fifth objective, it resolves itself into a structure resembling the New England basalts in miniature. Grains of magnetite, not visible with an inch objective are clearly made out. Some minute but wholly idiomorphic augites with magnetite grouped in lines along their outer boundaries are visible and there is very little olivine. A green secondary product stains the felspars. As the latter seem water-clear and fresh, this colouring material is probably derived from some ferro-magnesian constituents that have now disappeared. Under high powers plates of a light substance are detected filling cleanly cut joints in the porphyritic oligoclase. The surface of this substance is marked with minute figures, reminding one of the microlites in the Arran pitchstones. In polarized light, very good examples of polysynthetic twining form brilliant pictures. On the end of the slice furthest from the numbered label, there is a group of augites with devitrified glass and magnetite inclusions. One of the augites is twined.

Slice 10.—Porphyritic Basalt, north slope of Mt. Canoblas, half-a-mile south of last specimen. This slice shows to advantage under a two inch objective, the character of the base being just resolved and the relations of the porphyritic plagioclases being clearly defined. A few steam vesicles on the slice are seen filled

with radial zeolites. Some of these radiate, not from the centre outwards, but from one or more points on the circumference, inwards. They show a black cross, whole or in part, under the usual conditions. As in the other slices of this rock, there are crystals that present some perfectly sharp faces one or more of which are clearly corroded. Magnetite occurs in grains and aggregates. Towards the centre of the slide there is a very interesting augite with a line of inclusions parallel to its outer edges. The outer zone, beyond the inclusions, is of a lighter colour in plane light. The growth of the crystal was no doubt interrupted for a time and then resumed. The more recent addition is in optical continuity with the older central portions. With crossed nicols, a point of considerable interest is revealed—the crystal, in polarized light, is shown to be a remarkably fine twin. The trace of the composition plane is a line traversing the centre, and it will be noted that the newer accretions adapted themselves to the condition of elasticity of the parts around which they grew. In common light nothing of this structure is shown.

Slice 11.—Porphyritic Basalt, same locality as Slice 9. In general characters it resembles the other slices from German's Hill. Porphyritic plagioclases are plentiful, some being beautifully twined. They show some broken and some corroded examples. There are a few olivine pseudomorphs present. There is a twin felspar on this slice cut nearly perpendicularly to the brachypinacoid. The adjacent lamellæ extinguish at an angle of 37° and 34° respectively. Of course this might point to albite, oligoclase or microcline, but there are sufficient grounds for deciding that the felspar is oligoclase. The study of these slices shows that the micro-porphyritic crystals in these rocks are allogenetic in origin and were floated up probably from greater depths, and in this way received the broken and corroded appearance they usually present under the microscope. One other crystal on this slice is suggestive of some facts recently dealt with by Professor J. W. Judd.* There is little doubt left in the Writer's mind that in the

* On the Growth of Crystals in Igneous Rocks after their Consolidation—Quart. Journ. Geol. Soc., Vol. XLV., p. 175.

rock under examination there is abundant evidence that some of the crystals have had two separate growths, but whether this took place after consolidation is not so easy to decide. On Slice 11 there is a dome-shaped zoned crystal, that shows a bright border when the centre is extinguished. As the line of extinction for the central parts is passed, and the stage rotated, the zone of extinction is seen to travel outwards without any kind of break until it reaches the edges of the crystal. It would seem that this particular crystal grew very slowly, from a magma that was itself slowly altering through the removal of successive crops of crystals.

Slice 12.—Fine-grained Basalt, near the Race Course, Orange. This is a portion of a basaltic stream that flowed down from Mt. Canoblas, about six miles distant. In hand specimens the rock is of a rather bright blue-black colour. It breaks with a conchoidal fracture and the clean fractured surfaces show a finely crystalline glistening structure. None of the constituent minerals are visible to the unaided eye. When large masses of this rock are broken, it is interesting to notice how large drops of water are set free, spreading on the surrounding stones like the large drops of rain that precede a thunderstorm. This is noticeable where the stone shows no trace of decomposition, at a depth of twenty feet from the surface. Under the microscope in ordinary light, the rock shows itself as a felted mass of plagioclase crystals. Some of these crystals are cruciform in shape, and sometimes three or four individual crystals aggregate diverging from a certain point. These crystals seem equally distributed through the slide, and show no disposition to form a fluction structure. The feldspars appear to be of two generations, the large feldspars of which there is only one good example on the slide being allogenetic and much corroded. In polarized light allotriomorphic granules of the usual ferro-magnesian minerals, augite and olivine, are recognized, wedged in between the feldspars. There is a fair quantity of interstitial glass, mostly showing incipient devitrification. Magnetite occurs in three forms—first in perfect cubes and grains penetrating by turns every mineral in the slice, secondly, as micro-

scopic dust rendering the glassy portions of the rock almost opaque, and thirdly, in rods that are often bent and broken. A drawing from a microphotograph of this beautiful rock is given on Plate XXI., fig. 1. The figure is fairly typical of the basalts found in so many localities around the town of Orange. In fact I have slides cut from basalts collected from places fifteen and twenty miles apart, showing the structure figured so closely as not to be distinguishable. The structure reminds one too, of many of the Tertiary basalts of Europe and the United States of America. Immediately around Orange, basalts structurally similar are found at Lucknow, Forest Reefs, the Race Course Paddock, and at the the Corporation Quarries.

Slice 13.—From a basalt flow, about half way between the town of Orange and Mt. Canoblas, New South Wales. The general structure of this slice is best made out with a two inch objective. When the slice is placed transversely on the stage of the microscope, great streams of felspar are observable up and down the field. Scattered through this flow structure, are aggregations of magnetite and augite granules. These are mostly confined to the "eyes" formed by the wavy outlines of the streaming felspars. In polarized light, a great deal of glassy matter can be detected in some of the olivine granules. There are no idiomorphic minerals, other than magnetite and felspar. All these basalts, collected around Orange had a common source in the Canoblas. The whole series of volcanic material is made up of several distinct flows, and at present there is no evidence to show that any considerable time intervened between the successive outbursts. I have not been able to discover any interbedded material that would point to a period of rest, but the material on hand, collected during my own few short visits to the mountain, is hardly sufficient to settle anything on this point. A microscopic examination of the various lavas shows that the volcano poured out acidic and basic, as well as rocks of intermediate composition, which latter will probably be classed with the andesites. The great bulk of the acidic and intermediate rocks have disappeared through denudation, but

good examples can be collected both *in situ* and from tuffs and agglomerates. The porphyritic basalt referred to, is an older and more acidic rock than the ordinary basalt. In these basalt flows we have the records of probably the most extensive Tertiary volcano in New South Wales, as traces of its activity can be noticed over nine hundred square miles of the country around. The rich gold bearing drifts of the Forest Reefs, Lumpy Swamp, and Lucknow, were buried under these basalts. Many interesting relics of an extinct vegetation have also been discovered beneath the lavas that flowed down from the Canoblas.*

Slice 14.—Basalt from twenty miles north of Armidale, New South Wales. To the unaided eye, the feldspars and magnetite are visible in this slide. Under the microscope, in ordinary light, the rock shows well shaped plagioclases together with augite and olivine, set in confused masses in an almost opaque base. The average length of the plagioclases may be put down at the one-eightieth of an inch. In the thinnest parts of the slide, the opaque base is made out to be a devitrified glass, thickly set with magnetite dust. The large masses of augite next demand attention. This mineral is seen pierced by the lath-shaped feldspars, giving rise to an ophitic structure. Olivine is also present, being recognizable, under crossed nicols, and also in plane light, by its ground glass appearance. The opacity of the ground mass and the water clear character of the feldspars give this rock a very interesting appearance under the microscope.

Slice 17.—Basalt from Vegetable Creek, New England. In hand specimens this shows as a compact dark-bluish rock. Few, if any, of the constituents are visible to the unaided eye. It weathers to a dull grey, coloured with patches of red. Under the microscope in common light, micro-porphyrific feldspars are developed. The longest of these feldspars goes up to one-fiftieth of an inch; their average may be put down as one-

* Mueller, Observations on New Vegetable Fossils of the Auriferous Drifts, Decade I., p. 27, *Ibid.*, Decade II., p. 5; Ann. Report Dept. of Mines, New South Wales, 1875, p. 125.

hundredth of an inch long. There is no disposition on the part of the felspars to form lines of flow. Most of the large felspars are compounded, nearly all showing dark and light zones, with crossed nicols. The olivines are micro-porphyritic, and all show traces of decomposition. The secondary product is of an orange-yellow colour, contrasting with the green serpentinous matter that has a like origin in other basalts. One rather thick zeolite on this slice shows a perfect series of coloured rings intersected by the arms of a dark cross.

Slice 18.—Basalt from Vegetable Creek, Emmaville, New England, New South Wales. In ordinary light, with a low power idiomorphic crystals of olivine, plagioclase and magnetite are seen scattered through a finely granular ground-mass of augite and felspar microlites. The olivines are fairly fresh although greatly cracked and broken. The order of consolidation seems to have been 1. magnetite, 2. olivine, 3. felspar, and 4. augite.

Slice 19.—Basalt from Vegetable Creek, Emmaville, New South Wales. This is another example of a basalt with a granular augitic ground-mass. The magnetite occurs in grains and patches. The olivines are idiomorphic and much corroded, and in some instances contain cores of the ground-mass. There are two very characteristic olivines nearly parallel to $\infty \bar{P} \infty$ on this slice showing inclusions and corroded edges exceedingly well. Twins of olivine are rare in most basalts I have met; one example occurs in this slice.

Slices 20 and 21.—Basalt from Dubbo, New South Wales. This basalt occurs in a great stream, running north and south, to the east of Dubbo. Some patches about the township are probably remnants of a later eruption. Macroscopically, the rock exhibits a finely intimate crystalline structure. It is of a deep blue-black colour, with a shade inclining to green. It is remarkable for the quantity of steam vessicles that honeycomb the rock. These cavities are often drawn out in one direction. Under the microscope, the slice is seen stained a rich brown-red colour in patches. Broad prismatic compound plagioclases are observed penetrating

allotriomorphic augites. There is no ground-mass, the spaces between the plagioclases being filled with augite, olivine and isotropic glass. The olivine is idiomorphic, but has suffered greatly from secondary alteration. The rich brown-red patches, already referred to, are the result of this alteration, and the process can be noted in every stage. Large brown-red masses may be seen in the slice, some preserving the characteristic shape of many of the olivines of basalts, that is, in boat-shaped figures that represent slices either parallel to OP or to $\infty \bar{P} \infty$. Other sections are to be found in this slice with an as yet untouched nucleus of clear olivine. The magnetite occurs in grains, and is no doubt, a mineral of the first consolidation. Besides these grains, there are rods of magnetite, very often immediately around the most altered olivines. These rods are most probably, of secondary origin. The plagioclases are seen to have more complete terminations than is usual in basalts. In polarized light, the almost holocrystalline character of the rock, with the broad prisms of felspar give the slice a particularly rich appearance. The augite, too, polarizes in colours rather more brilliant than usual. A few of the idiomorphic olivines are seen to contain cores of devitrified glass.

Slice 22.—Dolerite Basalt, eight miles north-east of Dubbo. In hand specimens, this rock would, without doubt, be called a dolerite. A microscopic examination alone, of some of the slices would lead one to term the same rock a diabase. However, when studied in the field, there is no doubt left in the mind of the geologist that he is dealing with a coarse-grained and altered basalt which graduates through every variety into the average basalt. Macroscopically, the rock has a mottled greyish-black crystalline appearance. It weathers to a light granular grey. In fractured chips, it shows a faint green on the translucent thin edges. In ordinary light under the microscope, it has the general appearance of an ophitic dolerite, with grains and aggregations of magnetite scattered through the field. The augites are idiomorphic and of a rich brownish-yellow colour. They are much fractured and

broken. Sections, nearly parallel to the clinopinacoid are recognizable by the cleavage and the angles of extinction. There is a great deal of green chloritic or serpentinous matter in the slice. This can be detected by the unaided eye on holding the slide up to the light. It might be difficult to account for this mineral, were it not that it is sometimes found completely filling the outlines of what must, at one time, have been olivine. This secondary product is easily removed by dilute hydrochloric acid. In polarized light, the slice is decidedly doleritic in structure. There is a considerable amount of isotropic glass, in which hair-like bodies often showing a radial structure are developed. The exact nature of these I have not been able to determine.

Slice 23.—Basalt from Cemetery Hill, Carcoar, New South Wales. In hand specimens this seems to be denser than the average western basalts of New South Wales. Its crystalline structure is just apparent to the unaided eye. Under the microscope well developed laths of plagioclase is the most abundant mineral. Augite is present in large irregular aggregations pierced by the laths of felspar. The glass, both isotropic and devitrified, is rendered almost opaque by magnetite dust. In a few places on this slide, the magnetite is aggregated into rods that cross each other at right angles, forming a latticed structure reminding one of the well known structures figured by Zirkel.

Slice 27.—A micro-porphyrific Basalt from Mt. Pleasant, Bathurst, New South Wales. This slice was taken from a hill that forms part of a basaltic flow near Bathurst. This rock is a fine type of the micro-porphyrific structure of some basalts. The constituents present are 1. plagioclase, 2. augite, 3. magnetite, 4. olivine, 5. glass, and 6. partly devitrified base. A streaming of the felspars is splendidly developed in some of these slices (Nos. 27 to 35). The augite is in a perfect state of preservation, and indeed the more unstable olivine is altered hardly more than along the cracks. The augite occurs in two ways—first, as allotriomorphic granules in the ground-mass, and secondly in large idiomorphic crystals which occasionally give very fine optical sections.

Slice 32.—On this will be found a section of augite nearly parallel to the clinopinacoid ($\infty P \infty$). The extinctions from the vertical axis is 36° , and the angle between oP and $\infty P \infty$ is $74^\circ 5'$. Under crossed nicols, the crystal is seen to be beautifully typical of the "hour-glass structure," so rarely observed in Australian rocks. It will also be noticed that the augite is partially penetrated by a plagioclase. The granules in the base are not all augites. By treating the slice with dilute hydrochloric acid, many of them are removed; besides, in polarized light, the olivine granules are rather more brilliant than those of augite. To observe properly these augite granules, it is necessary to remove the secondary constituents as well as the olivines and magnetite. This can be done very effectively I find, by treating an uncovered slice with warm hydrochloric acid for about three hours. A few of these slices show glassy matter, but not in any great quantity. The general structure of this rock is best seen under crossed nicols with a low power. The slice is then seen with lath-shaped feldspars streaming round the porphyritic constituents. Both augite and olivine polarize brilliantly, in fact they seem to stand out in relief in the fine-grained ground-mass in which they are set; and any of these slices forms excellent examples of the micro-porphyrritic structure of basalts. The sharp contrast between this and other basalts is well seen by an inspection of the figures on Plate XXI.

Slice 34.—Basalt from Bald Hills, Perth, New South Wales. In this slice, aggregations of augite are recognizable with the unaided eye. Under the microscope, some of these are beautifully zoned, and in one aggregation, a partial hour-glass structure is clearly shown in polarized light. A cavity is seen in the slice that has been filled with a zeolite radiating from three different centres, and showing parts of three crosses under crossed nicols. The magnetite grains often give the outlines of perfect cubes. A few perfect forms included in the clear olivines measure the one-six hundredth part of an inch in diameter, less perfect forms going up to the one-hundredth of an inch. The serpentine into which the olivines of this basalt alters is always of a greenish colour.

No complete pseudomorphs occur, the alteration not having proceeded beyond the cracks of the olivine crystals.

Slice 36.—Intrusive basalt from Kiama, New South Wales. This rock is intrusive in the Permo-Carboniferous rocks of Kiama. Examined in hand specimens it is seen to be a dense basaltic-looking rock very fine-grained in texture, with porphyritic crystals of a striated felspar. These porphyritic masses sometimes measure as much as a quarter of an inch across. Examined in thin slices the rock is seen to consist of a felted mass of plagioclases, wedged between which are granules of augite and devitrified glass rendered dense by magnetite dust. The lath-shaped plagioclases are traversed by numerous, long, colourless acicular rays. Nothing is known of the nature of these bodies, but they occur in similar rocks all over the globe. Zirkel thinks they belong to some undetermined product of devitrification.* They sometimes stand parallel one with another, or are grouped in the shape of fasciculi and bundles. The plagioclases are of two generations. The porphyritic felspars are of allogenetic origin and have evidently floated for a long time in a liquid magma. They are corroded to a very notable extent, indeed. I could find no sections in the slide suitable for measurement, with a view to determine the species. They are however, probably identical with crystals of a smaller stature that are also present in this slide. One of the latter is twinned so as to extinguish at almost equal angles, on either side of the trace of the composition plane. The extinction is inclined 35° to one side and 34° to the other. The felspar is, therefore, under the circumstances, probably oligoclase. Magnetite is also present in well-formed cubes. The pyroxene of the rock is also porphyritic and of a rich yellow colour by transmitted light. I have only had the opportunity of cutting two slices of this rock—hardly sufficient material I think, on which to found a name. For the present, therefore, we shall designate the rock an intrusive basalt. The Slices 36 and 37 show all the characters to which I have referred.

* Zirkel's Microscopical Petrography of the Fortieth Parallel, p. 232.

Slice 38.—Leucite Basalt from Harden, New South Wales. In hand specimens, this rock appears as an exceedingly fine-grained basalt with very minute sparkling crystals, suggestive of these rocks. Where a thin slice is made and placed under the microscope the first characteristic noted, will be the entire absence of felspars. There are certainly lath-shaped prisms in the rock, but, on due examination they prove to be augites. Augite also occurs as a micro-porphyrific ingredient. Plates of a finely striated mica are also present. The whole character of the rock and a rather peculiar appearance of the olivines in particular, remind one of the leucite rocks from El Capitan and Byerock, New South Wales. The El Capitan rocks have been described by the writer,* Mr. (now Prof.) T. W. E. David, B.A., and Mr. W. Anderson.† The Harden rock resembles, in general microscopic characters, the leucite basalt from El Capitan. The micro-photograph exhibited gives a general idea of the rock magnified to thirty diameters. The minerals porphyritically developed, are, leucite, olivine and aggregates of magnetite. The ground-mass consists of granular aggregates of leucite, augite, and magnetite. The leucite is fairly abundant in the slices, showing as usual, the radial and concentric inclusions, that seem to characterise this mineral wherever it is found. Good examples of this structure will be readily found in the sections. The micro-porphyrific olivines in every instance show signs of decomposition into a yellowish-green serpentinous matter. It is very probable that the mica is a secondary product in this rock. Leucite basalts are rocks, so very rare, that this additional occurrence in New South Wales is of great interest and important enough to justify a separate memoir on its distribution, and structure, as soon as the material collected can be worked up.

Slice 39.—Leucite Basalt from Harden, collected about half a mile from the last slide. This rock is, without doubt, from a tertiary basalt flow. In Europe and North America leucite is

* Proc. Linn. Soc. N. S. Wales, 1887, Vol. II., p. 974.

† Rec. Geol. Survey N. S. Wales, Vol. I., 1890, Part iii., p. 153.

not known in rocks older than the Tertiary. Australia furnishes no exception to this rule. I had an opportunity of examining these interesting rocks in Central New South Wales, and there is no doubt but that they represent fragments of comparatively recent lava flows. The Harden basalt is also a Tertiary lava flow. The slices of this rock are seen studded with magnetite in clearly and sharply defined grains, ranging from one-thousandth to one-two-hundredth part of an inch in diameter. The largest leucite is not more than the one-fiftieth part of an inch in diameter. A few good examples of the peculiar leucite inclusions are present on this slice. One will be found about the one-hundredth part of an inch from the ink dot on the cover glass. There is a secondary mineral of a rich reddish-brown colour scattered through the slice. It is not dichroic and is soluble in weak hydrochloric acid. There is a crystal of olivine, that has been broken along its principal axis; this, with other evidence of a similar kind, shows that these micro-porphyrific olivines floated as fully developed crystals, in the liquid or pasty magma before the consolidation of the rock. They are probably allogenic in origin.

Slices 41 to 46, inclusive, are all examples of New South Wales leucite basalts. I collected them from localities where the rocks were developed to most advantage. A considerable likeness will be found to exist between parts of these slides and some of the typical leucite basalts figured by Fouqué and Lévy* in their splendid work, and by Zirkel in his work on the Petrography of the Fortieth Parallel (Plate 5, fig. 4.)

Prof. T. W. E. David late of the Geological Survey of New South Wales was the first to describe tachylytes or basalt glasses from this Colony.† Basalt glasses are by no means uncommon as fragments and lapilli in basaltic country. But it is rare to find this interesting rock *in situ*. The best occurrence with which I

* Mineralogie Micrographique, Pls. 48, 49, 50, and 51.

† Geology of the Vegetable Creek Tin-mining Field, Government Printing Office, Sydney 1887; and Proc. Linn. Soc. N. S. Wales, Vol. II., (New Series) p. 1078.

am acquainted is to be found on the Blayney-Carcoar Road about a quarter of a mile from Mr. Pratt's Residence. In hand specimens, the rock shows a rich blue-black colour on freshly fractured surfaces. It breaks easily into small irregular masses. On weathered surfaces, a brown crust is noticeable which can easily be detached. Groups of sphærolites are at once recognised studing the rock thickly in some parts. Many of these are a quarter of an inch in diameter, and, on polishing the specimens, their radial character becomes apparent. The rock is easily fused to a black enamel. Its powder is not magnetic. I treated a sample in concentrated hydrochloric acid for five days, keeping it just below boiling-point for twelve hours. Small quantities of flocculent silica were separated and on completion of the treatment I found that a residue of 82·5 per cent was left.

According to many authors, the rock should be called a "hyalomelane." But petrologists seem inclined to abandon the distinction between tachylytes and hyalomelanes, based on their solubility in acids.*

Slice 47.—Tachylyte, Carcoar, New South Wales. This is an exceedingly difficult rock to slice and in the thinnest sections the sphærolitic bodies remain opaque. When examined under the microscope each sphærolite is seen surrounded by a crystallization halo. This structure is admirably illustrated in every slice I have made of the rock. When the edges of these sphærolites are examined under a high power they remind one of the rolling margins of cumulus clouds. The minute bodies seem first to have gathered together into little masses and then to have been drawn by the neighbouring larger masses into one great aggregation, leaving the surrounding magma quite free from every individualized substance. By transmitted light, the rock is a rich brownish-red and the spaces cleared by the crystallization halos a bright yellow. All the cleared spaces have nuclei except when the section has just cut the outer zone of a halo. As already stated, I

* J. W. Judd and G. A. Cole—On the Basalt-glass of the West Isles of Scotland. *Quart. Journ. Geol. Soc.*, 1883, Vol. xxxix., p. 444.

have failed to reduce the sphærolites to a degree of tenuity which would permit light to pass. I have collected some few, and have seen other examples of basalt-glasses, many showing clear absorption spaces around the globulites; but altogether the Carcoar rock is the most beautiful example I know. The general appearance of slices of this rock under the microscope is shown in Plate xx., figs. 1 and 2.

Slice 49.—Tachylite from Vegetable Creek, New England, New South Wales. This resembles the Carcoar rock generally in the microscopic slide. In hand specimens, the New England rock shows a bright blue skin which gives it a very remarkable appearance. Like the Carcoar rock also, it is easily fusible and its powder is not magnetic. Sphærolites are well developed and have the appearance of globulites massed together. But there is no halo around them free from globulites which gives the Carcoar rock so interesting a structure. The globospherites are quite opaque and the glass is of a rich brown colour. In the Vegetable Creek specimens, the globospherites are large and well developed both as individuals and congregated in masses, set in a dark brown glass, but as already stated with no clear space surrounding them.

Slice 84.—At the Battery Hill, Lachlan River, above Cowra, pieces of basalt-glass are frequently found, but I have not been able to discover whence they are derived. The fragments occur in the drifts, sometimes being two and three inches in diameter. The surfaces of these specimens are pitted in a very curious fashion and show a peculiar etched-glass appearance suggestive rather of corrosion than of weathering or attrition. The Battery Hill basalt-glass is easily fusible before the blowpipe and the powdered stone is magnetic. Under the microscope incipient sphærolites are plentiful as well as flakes of a monoclinic pyroxene. A little magnetite is also present. The colour, by transmitted light, is a deep brownish-yellow. At Monkey Hill, near Hill End, fragments of a basalt-glass may be collected. I saw a few specimens six inches in diameter. *Slice 84A* is prepared from one of these. Under the microscope, it shows a rich red-brown shade. Before

the slice is reduced to the required thinness, the rock appears of a blood-red colour. As far as I can make out, it is a perfect glass, there being no individualized matter in any of the slices I have prepared. As these rocks are almost as interesting in hand-specimens as in thin slices, I have preserved a few chips for inspection. The Carcoar basalt-glass will be found numbered "200" and the Battery Hill and Hill End specimens "202" and "201" respectively. A thick polished slice of the Vegetable Creek rock is numbered "203."

Slices 85 and 85B.—Magma Basalt from Gulgong, New South Wales. This interesting rock was collected by Mr. M. Orlovich about ten miles north of Gulgong. It has the general appearance of a basalt-glass in hand specimens, but crystals of pyroxene are visible to the unaided eye. Under the microscope, this rock is seen to consist of brown glass, in which are imbedded crystals of a monoclinic pyroxene. The glass contains considerable quantities of those needle-shaped bodies that are often seen both in the glass and felspars of basalt, but their exact nature is not known. They are most plentiful in slices which show patches of clear glass. There is very little of this in Slice 85, but instead there is a remarkable development of large rods which cross and cover the field in confused masses. Some of these rods are sensibly pleochroic. They are, without doubt, incipient crystal aggregations. Incipient crystals are also to be seen in faint lines, having other lines branching to the left and right at right angles. A most interesting skeleton crystal of augite is also present on this slice.

Slice 60.—Hornblende Biotite Granite from Bathurst, New South Wales. In hand-specimens, this rock shows all its minerals to the unaided eye. Prisms of hornblende are common, measuring one-eighth of an inch along the vertical axis. Nests of biotite are also clearly visible. These two minerals scattered through the customary complements of quartz and felspar give the rock, at a distance, a light grey colour, with just a shade of blue. Occasional twins of orthoclase may be discovered by reflected light. Thin flakes of biotite can be detached and show all the optical

properties of black mica. Besides the orthoclase, striated feldspars can be picked out in reflected light. In this respect, the granite differs from most of the Australian rocks that I have observed. Under the microscope Slice 60 is fairly characteristic of the rock, except that the hornblende constituent is not well represented. There are half-a-dozen characteristic flakes of biotite in this slice. These are all found to be strongly dichroic. When rotated above the lower nicol, they are a light yellow when the vertical axis of the crystal is parallel to the plane of vibration of the light, and dark indeed almost black, when the cleavage corresponding to the lateral axis is parallel to this plane. There is rather more triclinic feldspar in this slice than is usual in slices of true granites, so that, were it not that I had studied the rock in the field, I should be inclined to assign it a place among the quartz-mica-diorites. The quantity of triclinic feldspar present is most easily discovered by examining the rock under crossed nicols. The quartz is of a character, usual with granitic rocks, showing broad plates of colour with the nicols crossed. Under high powers, the quartz is seen to contain a large number of fluid cavities. Some of these appear quite full, and many show that they contain bubbles—probably of carbonic acid gas. Some of the most minute of these cavities have bubbles exhibiting spontaneous movements. I have examined a great number of these and noticed that the smallest bubbles are the most active. Some vibrate too fast for the eye to follow their motions while others move more slowly round the containing cavities. Slices 62 and 63 show rather more of the fluid inclusions in the quartzes than is usually seen. I never noticed a gas cavity in the feldspars of this rock.

A rather distinctive character of quartz in this rock is the presence of large amounts of hair-like bodies that run for long distances through the silica. Occasionally they branch at the ends, I have also noticed them bend away at a sharp angle, and also to radiate from a single point. Similar bodies termed trichites have been observed in other granites. They occur in a granite at

Galway Bay, Ireland.* Slices 61 to 69 inclusive, present very much the same characters, the minerals present in them being 1. quartz, 2. orthoclase, 3. plagioclase, 4. biotite, 5. hornblende, 6. sphene, and 7. muscovite.

Slice 65.—The granites of Bathurst and Moruya often contain inclusions of fine-grained granitic material, with a semi-schistose structure. These inclusions are of great interest as, when studied, they will probably throw some light on the origin of the rocks which contain them. This slice is cut so as to show a portion of the granite and part of one of these inclusions. On this account the slice may deserve a short detailed description. At a first glance, it will be noticed that there is no hard and fast line separating the inclusions from the normal rock. In fact, the inclusion seems, when examined under the microscope, merely a finer variety of the same rock. The minerals present are identical, their mode of occurrence is the same, with the exception that the quartz is rather poorly represented and hornblende is always absent. However, under crossed nicols, it must be admitted that the inclusions have something more of a clastic appearance than the normal rock. Both orthoclase and a triclinic felspar are present in the inclusions. In the portion of the slide representing the normal granite, a microscopic grain of quartz will be seen, completely surrounded by a fringe of fibrous hornblende. This is in the vicinity of other quartzes and may be taken as typical of the general appearance of the quartz in this granite. No inclusions that I ever examined contained quartz at all resembling this occurrence. All the quartzes which I have noticed in the "inclusions" seem surrounded by other minerals, rather than filling up the interspaces between the other constituents as it does in the normal granites. It will be noticed too that under the microscope with crossed nicols, the inclusions show a decided tendency to that structure known as a "mosaic field." The structure of the inclusions is a much nearer approach to a hornfels

* Observations on the Structure of Quartz-Granites, by Prof. E. Hull, F.R.S.—Geol. Mag., Vol. x., p. 193.

than to a granite. This undoubtedly lends some weight to my own opinion that these inclusions represent fragments of clastic rocks, caught up in the granitic magma. It is hard to see how they can be due to any selective influences in the cooling mass.

Slice 70.—Granite from Moruya, New South Wales. This is a rock well known in New South Wales and Victoria. It is extensively used for building and ornamental purposes. The columns in front of the General Post Office, Sydney, are of this material. In colour and general structure it resembles the Bathurst rock. Under the microscope the following minerals are recognized 1. quartz, 2. orthoclase, 3. triclinic feldspar, 4. biotite, and 5. hornblende. The orthoclase is nearly always cloudy and seldom idiomorphic. In one instance on this slide, cross-banding or cross-twinning shows beautifully under crossed nicols. The triclinic feldspars (oligoclase) are, as usual, well brought out in polarized light. Both feldspars occur without any crystalline outline. The quartz is moulded around the feldspars and hornblende. The biotite shows a wavy structure as if subjected to a bending or twisting. Large masses of quartz, although seemingly continuous in ordinary light, are shown in polarized light to consist of many distinct patches each one of which shows a different interference colour surrounded by a prismatic girdle. From a microscopic examination, one would conclude that the rock is of an enduring character, the feldspars though cloudy not being kaolinized to any considerable extent and there is no notable excess of fluid cavities. I notice too the absence of the slender hair-like bodies that are present in many other Australian granites.

Slice 72.—Hornblende Biotite-Granite from Burdekin River, Queensland. There is a large development of this rock above Bowen on the Burdekin River, and on the Queensland coast. Macroscopically it would be described as a grey granite, hornblende being plentiful in every specimen. Under the microscope the quartz is water-clear and contains an abundance of fluid cavities. Many of these cavities resemble the forms figured by Mr. Sorby

in his paper on the microscopic structure of crystals.* Some of these cavities can easily be seen with a power of three hundred diameters. As in other granites, I notice that the smallest cavities contain the most active bubbles. Many of the broad patches of quartz break up into smaller patches under crossed nicols. An examination of the slides shows that the quartz was the last mineral to solidify. The rock contains both orthoclase and plagioclase, but the latter felspar being comparatively speaking, rare. There is a good deal of felspar exhibiting in polarized light a cross-banded structure, the bands crossing each other at an angle of 90° . Slice 72 contains some very characteristic hornblendes around which the quartz and felspar are seen to be perfectly moulded. Biotites on this same slide seem more twisted and broken than in any Australian granites I have met. Microphotographs of some of these interesting examples are exhibited with this paper. These biotites contain inclusions of a mineral very much resembling magnetite. Magnetite occurs also as an inclusion in the hornblendes.

Slice 73.—Sphærolitic Quartz Porphyry from Carcoar, New South Wales. This is a rock intimately connected with gabbro and other basic rocks near Carcoar. It occurs in dykes and veins cutting through the intrusive basic rocks and sometimes through the Silurian slates of the district. In hand-specimens, the rock is of a very fine grain and of a cream yellow colour. Quartz is the only individualised mineral visible to the unaided eye. Quartz however, is not very plentiful, four or five patches being the most that I have noticed on any slide. The bulk of the rock is remarkably free from inclusions, if we except some lines and stains of ferrite in the slices which I have prepared. Under the microscope in common light, the felsitic character of the rock is at once apparent. The radial structure of the sphærolites can also be made out by a nice adjustment of the sub-stage illumination. It is in polarized light, however, with crossed nicols, that the beautiful and characteristic structure of the felsitic base is seen.

* Quart. Journ. Geol. Soc. London, Vol. xiv., p. 453.

The sphærolites too, are seen to advantage, showing the arms of a black cross very distinctly. The sphærolitic quartz-porphyry, described and figured by Mr. W. Anderson* bears a striking resemblance to this rock. Fig. 2, on plate II. A, of Mr. Anderson's paper agrees with the characters of part of Slice 73.

Slices 75 and 76 are quartz felsites from Sunny Corner. These rocks have been so well described by Mr. Anderson in the paper just referred to, that there is no object to be gained in going over the same ground again. My slices show the corroded quartzes remarkably well, as also the flow structure referred to by Mr. Anderson. There are no sphærolites present in my slices.

Slice 77.—Quartz-felsite from ten miles south of Dubbo, New South Wales. This rock is found intrusive in granite. Under the microscope it shows a micro-felsitic base in which there remain obscure traces of triclinic feldspars. The quartzes occur in water-clear grains with corroded edges. In hard specimens, wavy lines of flow can be seen spreading round the porphyritic quartz crystals. This rock might be called a rhyolite.

Slice 78 is another sample of the same rock.

Slice 79.—Quartz-felsite from Peak Hill, New South Wales. This specimen is taken from the top of Peak Hill, near the locality known as Maguire's Lease. In hand specimens it appears as a grey rock of a rather flinty character. Under the microscope it is found to contain a surprising quantity of iron pyrites. In ordinary light the microscope reveals a brecciated structure. Fragmentary pieces are seen set in a felsitic ground-mass; boundaries between the base and these inclusions are very distinct. But a notable change is observed when the rock is examined between crossed nicols—the boundaries between the fragmentary rocks and the base disappear, and the whole field represents a uniform felsitic structure.

* Petrographical Notes on the Eruptive Rocks connected with the Silver-bearing Lodes at Sunny Corner, Mitchell, near Bathurst, with Plates II. and II.a, by W. Anderson, Geological Surveyor—Rec. Geol. Survey N.S. Wales, Vol. i., Part i., 1889, p. 16.

Slice 80.—Quartzite from Coronga Peak, Central New South Wales. Coronga Peak is the highest point of all that stretch of country between the Lachlan and Darling Rivers west of Long. 148°. From a distance this hill, which forms a notable feature in the landscape, has all the appearance of a volcanic cone. From more than one point of view it presents splendid symmetrical slopes. On examination, however, it proves to be a hill of Devonian quartzite. Under the microscope the quartz can be distinguished as primary and secondary—the secondary quartz acting as a cementing material between the original grains. From an examination of the latter, I would conclude that the material which went to build up these quartzites was derived from the denudation of a granitic area.

Slice 81.—Quartz-porphyry, from Langtree's, Nyngan and Cobar Road, New South Wales. Under the microscope it is seen to consist of corroded quartz crystals and broken feldspars in a greatly altered felsitic base. The alteration of the base has given rise to a structure resembling, in miniature, the globular weathering of some basalts. I have reason to think that this rock occurs extensively developed for a long distance south of the point whence my specimens were taken.

Although Tertiary volcanic rocks are developed over extensive areas on the western slopes of the Dividing Range in New South Wales, acidic and even intermediate lavas are by no means plentiful. In the Bathurst and Orange Districts, acidic lavas of Tertiary age are found on the Canoblas Mountain and over a considerable extent of country around the junction of Rocky Bridge Creek with the Lachlan River. These are the only instances known to me in the western slopes of the Dividing Range in this Colony.

Slice 82.—Trachytic lava, from the junction of Rocky Bridge Creek, Lachlan River. The cavities of this rock are filled with opals, many of which are splendid examples of fire opal. The rock has evidently been subjected to hydrothermal influences that have altered it considerably. Under the microscope it will be

seen that the material of the felspars has been removed or profoundly altered, as when the slice is placed between crossed nicols, the felspars remain dark while the surrounding rock lightens.

Slice 87.—Basalt, Nerriga, New South Wales. The following minerals are present in this rock:—1. plagioclase, in felted aggregations; 2. augite, in microporphyritic crystals; 3. olivine; and 4. devitrified glass. It will come under the heading of basalts.

Slice 93.—Augite-porphyrite, from Blayney, New South Wales. This rock is quarried for road purposes from an open cutting near the Roman Catholic Church, Blayney. In hand-specimens it resembles a diorite; but, when sliced for the microscope, it is found to be a very characteristic diabase. When examined under the microscope we find it is a rock as interesting as it is rare, so far as our present knowledge of Australian rocks goes. In general structure it appears as a fine-grained porphyritic rock, with a slightly greenish shade. The porphyritic ingredients are mainly a monoclinic pyroxene, augite and magnetite. These crystals are set in an exceedingly fine-grained ground-mass of the same materials. The pyroxenes are oftentimes beautifully zoned, and generally of a greenish colour by transmitted light. The porphyritic crystals are idiomorphic and have their usually sharp angles rounded, and generally show corroded outlines. The black patches of magnetite are seen, with a low power, to be rather aggregations of magnetite grains than individual crystals.

Slice 94 is another example of the same rock. A rock closely resembling this diabase occurs at Buchan, on the Snowy River, Victoria. It has been described by Mr. A. W. Howitt as a diabase porphyrite.

Slice 95 is a slide of the Buchan rock kindly sent me by Mr. Howitt.*

Slice 96.—Diabase, Carcoar, New South Wales. On the upper reaches of the Combing Creek, in a line with Mount Macquarie,

* Proc. Roy. Soc. Victoria, Vol. xviii., p. 7.

this rock occurs as intrusive masses. When sliced for the microscope in its general character it is found to be a compound of felspar, augite and magnetite. The rock is not quite holocrystalline, but if a detailed examination of the district were made, it would be found, probably, merging into the holocrystalline augite-plagioclase rocks of Carcoar.

Slices 96 to 101 are all examples of various textures in this rock. An inspection of the slices with the hand-lens is sufficient to detect augite sections of characteristic outline, parallel or nearly so, to the clinopinæoid.

Slice 107.—Gabbro, Carcoar, New South Wales. Gabbro rocks are very extensively exposed in the valley of Belebula, above Carcoar. The rock is locally called granite. All the ingredients are macroscopic, and in texture somewhat coarser than the average granite. In terming this rock a gabbro, I follow Professor Judd, who reserves the term "gabbro" for holocrystalline basic rocks, which would be called diabases if they contained a considerable proportion of unindividualized ground-mass.*

Slice 113.—McKillop's Paddock, near Carcoar. This is a rock much resembling a felsite in macroscopic characters. When sliced for the microscope it is found to be of clastic origin, but there is no doubt that the fragments of which it is composed were themselves felsitic. This rock is inter-bedded with Silurian slate.

Slice 118.—Diorite from between Forbes and Eugowra. This rock consists of an intimate mixture of fibrous hornblende, felspar and magnetite. As the slice is ground down, the rock shows a beautiful sap-green colour by transmitted light. The green hornblendic material is dichroic. Veins of a secondary felspathic material form seams through the rock; one of these is seen on the slice.

* Professor Judd—On the Tertiary Gabbro of Ireland and Scotland—*Quart. Journ. Geol. Soc.*, Vol. XLII., p. 61.

Slice 125.—Diabase porphyrite from near Cowra, New South Wales. In hand-specimens this rock resembles one variety of *verd antique*. It takes a fairly good polish. Under the microscope it is seen to consist of porphyritic feldspars enclosed in a micro-crystalline paste. This paste or ground-mass carries a great number of lath-shaped feldspars, which show a streaming structure in a perfect manner, as they flow round larger crystals. Grains of magnetite are abundant in this base. This is a Pre-Tertiary rock and before secondary alteration had produced the chloritic material, to which the rock owes its green colour, it must have in its structure and composition, resembled a porphyritic basalt.

The slices mounted on the Slides, numbered 119 to 125, are all specimens of this rock. The ground-mass is of a light greenish-yellow colour by transmitted light, and the large porphyritic feldspars of a milk-white shade. The latter have all become clouded, no trace of the original glassy appearance remaining.

Slices 126 to 129 inclusive. Diabase porphyrites, Red Hill, Wellington, New South Wales. These rocks are not at all unlike the specimens, just referred to, from Cowra. The rock is best seen in a railway cutting, near the Springs (now Dripstone) Railway Station, Western Line, New South Wales. It is intrusive in Silurian slates, which it has altered and contorted. In hand-specimens large crystals of feldspar, from one-eighth to one-half an inch in length, can be recognized with the unaided eye, embedded in a dark olive-green paste. When examined under the microscope the only minerals recognizable are feldspar, augite, magnetite and calcite. The feldspars and augites occur both porphyritically and as constituents of the base. The calcite is a secondary infiltration, filling the joints and fine cracks in the mass. This rock presents a very handsome appearance, and could be utilised for industrial purposes.

Slice 133.—Frost's Station, near Cobar, New South Wales. The specimen from which this slice was cut occurs adjoining Slice 81. The exact nature of the rock it is not easy to determine, but

it probably represents extreme alteration of a sedimentary rock. The quartzes in the slice exhibit "strain figures" much more perfectly than I have noticed in any other Australian rock. These strange shadows can be seen both in ordinary and polarized light.

Slice 145.—Hyalite from Springsure, Queensland. I have noticed splendid examples of hyalite in the basalts of Springsure, Queensland. Under the microscope they are quite clear and glassy. Between crossed nicols these hyalites show a certain amount of colour. From their constitution as amorphous silica they should remain dark. This colour I should attribute to internal strain rather than to any admixture of amorphous and crystalline silica.

Slice 151.—Quartz-felsite from twelve miles south of Dubbo, New South Wales. This rock might be called an altered rhyolite. In hand specimens wavy lines, caused by a flow structure, are readily recognised. Under the microscope, instead of sphaerulites a radial arrangement of microlites is seen set around a linear axis. Zirkel describes similar but more pronounced structures in some American rhyolites.*

Slice 104.—Intrusive rocks are so rare between Cobar and the Darling, that there is a special interest in recording an altered diabase from the Black Hills. The rock is vesicular, but all the cavities are filled with well crystallized calcite. The crystallized amygdules show the peculiar crossed striæ of calcite remarkably well. (Plate XXII., Fig. 1.) There is no recognizable pyroxene in this rock, but the large amount of chlorite which is present is most probably a secondary mineral derived from the alteration of the augites. The chlorite, moulded around and along the plagioclase laths, is certainly of secondary origin. I have cut about twenty slices of these rocks and they all present the character of this slide and Plate XXII., fig. 4.

Slice 134.—It has been stated more than once that the immense metalliferous deposits of Cobar are intimately connected with

* U.S. Geol. Explor. Fortieth Parallel, Vol. VI., Microscopical Petrography, p. 167.

eruptive rocks. I have examined the country about Cobar with considerable care, and have to record that there are no eruptive rocks within a radius of ten miles of the copper lodes and gold deposits of Cobar. When greater depths will have been reached in the working of the "Great Cobar" Mine, eruptive rocks may be met with. But so far as an examination of the country will show, no eruptive rocks can be found. At the Peak five miles from Cobar, there is rock interbedded in the highly inclined slates, which has been considered intrusive. Slide 134 is prepared from this rock. A microscopic examination hardly favours this view, my impression being that the rock is a much metamorphosed felspathic sandstone.

Slices 54 to 59 inclusive.—Hornfels. The rocks immediately in contact with the granites around Bathurst are good examples of the metamorphic rock, hornfels. In hand specimens it would be hard to believe that the rock is really clastic. It appears as a dense, black, glistening rock, having every appearance of an eruptive origin. This rock, however changes by insensible gradations in the field, into less altered varieties, until the normal sedimentary rock is reached. Blebs of quartz having a peculiar bluish opaline colour are very common in these rocks. In the slices, by transmitted light, it appears as normal quartz. Under the microscope in ordinary light, an abundant development of mica plates and chloritic matter are recognized. The micas are strongly dichroic, very uneven in their outlines, and for the most part, developed in fluidal lines which bend and wave round felspar and quartz granules. In polarized light, with crossed nicols, the most highly altered of these rocks break up into felspar mosaics, clearly revealing their clastic origin. Slice 58 contains a quartz crystal, around which the micas are developed in the manner referred to. An examination in the field, has satisfied me that these rocks have never been reduced to a plastic condition, but they bear every trace of having been subjected to great pressure, and brought within the zones profoundly influenced by the intrusion of neighbouring granites. A study of these rocks of clastic origin teaches

that an apparent fluidal structure may be developed in a rock which has never actually been in a fluid or plastic condition.

Slice 142.—Quartzite, Belarbigil Station, Talbragar River, New South Wales. In very many parts of these Colonies, basalts are found overlying Tertiary drifts. Sometimes these drifts have been altered to quartzites by the basalts. The present slide is a fair sample of the rock produced in this way. Under the microscope the quartz is seen preserving its original outlines, but in the cementing material, probably a finely granular quartz and felspathic sand, a good deal of secondary quartz has been developed. Quartzites produced in this way are common in the three Colonies of which the Writer has a knowledge, New South Wales, Victoria and Queensland.

There is a general impression that most of our rich gold deposits are connected with dioritic rocks. As a rule, this view may hold good, but my experience has taught me that very many of the so-called diorites are really more augitic than hornblendic in composition. As examples of this, I might refer to many slices that accompany this paper. Slices 102 and 103 are very fair examples of diabase rocks, in which no hornblende is present but that have been considered diorites. The rocks already described from Blayney, and Carcoar, are also examples of rocks into whose composition no hornblende enters, but which in hand specimens, undoubtedly resemble diorites. Some intrusive rocks from Gulgong and Parkes, New South Wales (See Slices 121, 122, 119) are certainly not typical diorites, although without a detailed examination in the field, it would be unwise to say that we may not have intrusive masses of augitic rocks, altered locally to diorites.

Slice 151.—Diorite from thirteen miles south of Dubbo. This is a good example of a holo-crystalline plagioclase hornblende rock. The rock is intrusive in granite, and in character very closely approaches the typical diorite.

Slice 155.—Porphyritic Diorite, from Bogan River, twenty miles above Nyngan, New South Wales. In hand-specimens this

rock is seen to be a crystalline granular compound of large hornblendes and a rather small quantity of felspar. In fact, the felspar seems merely a cementing matter. Some of the hornblende crystals measure half-an-inch in length. This slice is cut from a rather fine-grained variety of the rock. In all the slices that I have examined the felspars formed but a small part of the whole. There are no idiomorphic felspars. Either in polished blocks or in microscopic slices this is an exceptional and interesting rock.

Slices 137 to 141 inclusive. Dyke Rocks, from Kaiser, near Wellington, New South Wales. These are slices of a very interesting series of intrusive rocks that occur in the locality named. Slice 139 may be taken as typical of their general character. Under the microscope we can clearly distinguish a micro-crystalline ground-mass and embedded porphyritic crystals. The composition of the ground-mass is as follows:—1. Broad stretches of a felsitic-looking base, made up of very minute colourless felspar prisms forming an independent net-work. 2. Microlites that are slightly dichroic. 3. Brightly polarizing grains, probably quartz. 4. Opaque matter, pyrites or magnetite. In this ground-mass are porphyritic crystals of felspar, some striated and many of them very clearly twinned in broad plates. There are also larger felspars showing lines of growth resembling a zoned structure. These felspars are water-clear, and remarkably like quartz in ordinary transmitted light. Under crossed nicols their real character is revealed. Mica is also a porphyritic ingredient in flakes from one-thousandth to one-fiftieth part of an inch in length. These micas are strongly dichroic. The felspars contain transparent needle-shaped crystals that agree with the characters of apatite.

Slices 149 and 150. Felspar-porphyrite, Mount Harris, Lower Macquarie River, New South Wales. This rock was collected at Mount Harris, an isolated and conical hill rising abruptly from the great Tertiary plains of Central New South Wales. In hand specimens it is of a bluish-grey colour, resembling many of the more recent quartz porphyries; in fact, corroded crystals

of quartz are easily found on examining the specimens. On separating these quartzes from the rock, their surfaces are found to have a dull ground-glass appearance. On mounting these granules in balsam, they become transparent, and in this way I have discovered that they contain fluid inclusions with moving gas bubbles. A very interesting structure is discovered on submitting the slice to a microscopic examination. The porphyritic felspars are seen to be surrounded by a pseudo-sphærolitic fringe of radiating microlites. When two felspars occur close together, on the slice, I notice that a fringe surrounds the two crystals in one waved line, which conforms to the outlines of the crystals. This is the only Australian rock in which I have ever observed this fringe structure. I have very little doubt that these fringes are secondary products, intimately connected with the decomposition of the felspars.* In general microscopic characters, the rock is very much altered—the felspars are kaolinized and the clear patches, seen through the slice, are evidently devitrified matter, that once formed a glassy base. Pending a more detailed examination of these interesting slices, I think I may include this rock amongst the felspar porphyries.

Slice 162.—Felspar Porphyry from Mount Foster, Lower Macquarie River, New South Wales. A short distance from Mount Harris, there is another isolated, conical hill rising in a similar manner from the plains. In macroscopic characters it seems to differ from the Mount Harris rock; but a microscopic examination proves the two to be identical. The decomposing felspars give the rock a reddish tinge which does not show in the Mount Harris specimens. The pseudo-sphærolitic fringes and the peculiar corroded quartzes are also present. From a study of these rocks in the field I am of opinion that in Mount Harris and Mount Foster we have some representatives of the most ancient eruptive masses in New South Wales.

* Somewhat similar fringes have been described by Prof. Judd in a paper on "The Growth of Crystals in Igneous Rocks after their Consolidation"—*Quart. Journ. Geol. Soc.*, Vol. XLV., p. 183.

In the collection of slides presented with this paper there are slices of many sedimentary rocks, claystones, sandstones, as well as limestones. The sections of the limestones reveal nothing new or noteworthy by a microscopic examination. Most of them are of Silurian age, and from localities not yet recorded on our geological maps. They were collected at Mount Hope; Rookery Station, near Cobar; Twenty miles east of Rookery Station; Baloura sixteen miles from Nymagee; Mount Dijou, Curraweena Station, south of Bourke. In the purely sedimentary rocks an instance has been already noted of "strain structure" developed in quartz grains, by metamorphism or pressure due to neighbouring intrusive rocks and the slices of clay-slate rocks from Bathurst are of considerable interest, as showing the change from a pure claystone to a compact hornfels.

Amongst the slices prepared, will be found also, some examples of very fine serpentines from Mount Hope, Lucknow, Nyngan and Gundagai, but their microscopic structure is almost identical with typical serpentines so often described.

CONCLUSION.

A microscopic examination of our rocks points to the existence in Eastern Australia of every leading type from the vitreous to the holo-crystalline condition, both acidic and basic, and their general microscopic structure conforms to well known types of described American and European rocks.

In writing of American Basalts, Zirkel says,* "It is worth while to pause, and remark that in these widely remote quarters of the globe, the product of the solidification of a molten mass, although exposed to many casualties has, nevertheless, maintained a surprisingly close identity of microscopical composition." The remark applies in every particular to the Australian basalts described in this paper.

Within well defined limits, the structure of our basalts shows microscopical peculiarities that enable us to recognize certain

* U.S. Geol. Explor. Fortieth Parallel, Vol. VI., Microscopical Petrography, p. 253.

types of structure as characteristic of particular districts, for instance, a micro-slice of basalt from Orange can always be distinguished from similar rocks at Bathurst. See Plate XXI., figs. 1 and 2.

In regard to the order of solidification of minerals, as a rule nothing exceptional is to be noted in the material examined.

The cavities of some basalts are filled, as at Carcoar, with aragonite. There is nothing in the microscopic character of the slices to show that the lime for this mineral was derived from the surrounding rock. On the contrary there are Tertiary volcanic rocks at Rocky Bridge Creek with their cavities filled by opal, and hyalite, and the microscope shows that this material has been derived from the silicates of the rock itself.

As far as is yet known the great bulk of the eruptive rocks of New South Wales are basic in composition. Intermediate rocks are not common. Acidic rocks are rare.

There are extensive metalliferous deposits about Cobar, but the microscope reveals no intrusive rocks in connection with these deposits.

Many of our granites are suffering from a decay called by Dolomieu "*la maladie du granite*."* Carbonic acid gas, in the air, as has been suggested may have a good deal to do with this process of disintegration, but the microscope shows that to a certain extent the disease is internal. The quartz of some granites is seen to contain numerous gas cavities, and the cloudiness and incipient kaolinization of the feldspars is probably due to the absorption of the free gas they once held.

Many of the rocks called diorites are augitic rather than hornblendic, and therefore must be classed with diabase.

In the conversion of a clay-slate to a hornfels, as at Bathurst, the microscope shows that the alteration of the rock consists in a rearrangement of the old minerals, and the introduction of one

* Lyell's *Principles of Geology*, 11th Edition, Vol. 1., p. 409.

new one, namely mica. This corresponds with observations made on similar rocks in other parts of the world.

The wide distribution of Tertiary leucite rocks in New South Wales is a matter of considerable interest.

The specimens with which this paper deals have been collected over widely separated localities. There is material enough in any one district, for considerable petrological research, but it has been my purpose rather to indicate the wealth and variety of our material for work, than to give exhaustive details of any one field. Much of the matter furnished will I trust, prove new, and of some interest to Australian Geologists.

EXPLANATION OF THE PLATES.

Plate xx.

Figs. 1 and 2.—Tachylite from near Pratt's, Carcoar, as seen magnified 50 diameters, by ordinary light. Globospherites resembling sphærolites of devitrified matter, are surrounded by halos free from globulites, or other products of incipient crystallisation.

Plate xxi.

Fig. 1.—Basalt, from Orange, New South Wales, as seen magnified 50 diameters, in ordinary light, illustrating a type of structure common in Australian Basalts. The slice shows a "felted" mass of lath-shaped felspars; in the spaces between these felspars, olivine, augite, magnetite, and some glassy matter are developed.

Fig. 2.—Basalt, from Perth, near Bathurst, New South Wales, as seen magnified 50 diameters by ordinary light. Illustrating the microscopic structure of a micro-porphyrific Basalt. Porphyritic crystals of olivine, augite, and felspar, are set in a ground mass composed of granules of augite, olivine, and magnetite.

Plate xxii.

Fig. 1.—Altered diabase, Black Hills, Cobar, New South Wales, as seen with inclined nicols, and magnified 30 diameters. The cavity in the centre of the figure has been filled by secondary calcite, which is seen transversed by characteristic fine cleavage lines, intersecting at an acute angle.

Fig. 2.—Triclinic felspar in Granite, Moruya, New South Wales, as seen with crossed nicols, under a magnifying power of 20 diameters.

Fig. 3.—Micro-porphyrific Basalt, German's Hill, Canoblas, New South Wales, as seen in ordinary light, with a magnifying power of 25 diameters. A large augite is set in a very fine grained basalt.

Fig. 4.—Cross-twinning in Orthoclase as seen in Granite from the Burdekin River, Queensland, with a magnifying power of 30 diameters. The crystal is represented as it appears in polarised light, with the nicols crossed.

Fig. 5.—Basalt, from Vegetable Creek, Emmaville, as seen magnified 45 diameters. The figure shows a characteristic section of olivine decomposing along the cracks into serpentinous matter. The other minerals present are lath-shaped feldspars, granules of augite and olivine, magnetite in black opaque grains, and some glassy matter.

Fig. 6.—Basalt, Mount Pleasant, Bathurst, as seen with a magnifying power of 45 diameters. The figure shows a characteristic section of augite. This crystal exhibits an hour-glass structure in polarised light with crossed nicols.

Fig. 7.—Coarse grained Basalt, from Beni, Dubbo, New South Wales, as seen magnified 25 diameters with the nicols inclined. Large crystals of augite are seen penetrated by plagioclase laths giving rise to an ophitic structure.

Fig. 8.—Diabase porphyrite, Blayney, New South Wales, under a magnifying power of 30 diameters. Microporphyrritic crystals of a monoclinic pyroxene are seen, set in a granular base, made up of plagioclase, grains of augite and magnetite.

NOTE.—The figures of the plates have been all drawn from micro-photographs taken by the Author. It was not considered necessary to reproduce the map handed in with this paper, and referred to on page 186.

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ON SOME NEW SOUTH WALES AND OTHER MINERALS.
(Note No. 6.)

By A. LIVERSIDGE, M.A., F.R.S.,
Professor of Chemistry in the University of Sydney.

[*Read before the Royal Society of N.S. Wales, December 2, 1891.*]

MANY of the specimens from Broken Hill, referred to in the following notes and exhibited this evening, were collected by Mr. C. W. Marsh of Broken Hill, and forwarded to me for identification and description; Mr. Marsh's Collection also contained a large number of very interesting and characteristic rock specimens.

ANTIMONITE—Sulphide of Antimony.

From the Eleanora Mine, Hillgrove. The antimonite is in the form of small nodules, in a soft brown shale or clay-like matrix; the nodules are about $\frac{1}{8}$ " to $\frac{1}{2}$ " in diameter, and when broken open present a beautiful radiate structure.

ASBESTOS.

In calcium carbonate from the New Reform Gold Mine, Lucknow. This mineral occurs in veins or masses apparently five or six inches in thickness. It is of a white colour and fibrous structure; associated with it is some greenish steatite. The specimen looks like a mass of somewhat fibrous steatite, but on treatment with hydrochloric acid it almost entirely dissolves with effervescence and leaves a slight residue of white fibrous asbestos.

The calcium carbonate is dense, compact, and shows no tendency to cleave into rhombohedra.

BISMUTH—Native.

From Kingsgate, Glen Innes. Showing well-marked cleavage forms, some of the faces are nearly one inch across. Associated with quartz, bismuth carbonate and large crystals of molybdenite.

The second specimen of native bismuth shown is from Maryborough, Queensland. It occurs in masses of calcite which possess large and well-marked rhombohedral cleavage planes; cobalt is also said to occur in association with it, together with gold.

The occurrence of native bismuth in calcite is very unusual.

CALCITE.

From vugs in the Umberumberka Mine. In rounded groups of scalenohedra, of a greenish tint (much resembling prehnite in appearance) seated on grey granular limestone. In other specimens the calcite is in the form of flattened rhombohedra.

EMERALD—Beryl.

From near Vegetable Creek, New England; where it occurs in veins or fissures containing kaolin, running through the granite near its junction with clay slate. The crystals are mostly under a quarter of an inch in diameter and are usually much fissured or fractured. In colour they vary from shades of beryl green to fairly deep emerald green, but I have not yet seen any of the rich deep shade characteristic of the finest emeralds, nevertheless they afford good ornamental stones, fit for jewellery.

Many of the crystals occur in groups or bundles. Associated with them are tinstone, topaz, and other minerals.

GALENA.

From Umberumberka Mine, with coarsely crystalline fracture; this specimen is chiefly interesting on account of its containing intermingled scales of black mica.

HORNBLENDE.

A white variety with a radiate fibrous structure. In appearance it resembles tremolite, but requires further examination. The specimen exhibited is from the Ada Augusta near the Angus Mine, where it occurs in a fissure lode some four to five inches wide. With it is associated a good deal of quartz, some galena, blende and pyrites.

HYALITE.

A variety of opal but without its play of colours. Associated with green copper stains ; occurs in a gossan near the Acacia Dam, Broken Hill.

GARNET—Common.

In more or less perfect crystals (combinations of the rhombic dodekahedron and ikositetrahedron) of a dark red and almost black colour, embedded in calcite and associated with a dark green massive and a black fibrous hornblende. From the Acacia Dam, Broken Hill.

Other specimens are massive with a granular structure.

Another specimen, also with a granular structure, in this case the grains show more or less perfect crystal faces of a red-brown colour; cutting through the mass are some small veins of white quartz. Mr. Marsh states that it occurs as veins and irregular deposits running through the basic rocks and mica schists of the Broken Hill district, and seldom with the granitic rocks, and that it is usually associated with the argentiferous lead deposits.

HÆMATITE—Auriferous.

Mount Morgan, Queensland. In mammillated stalactitic masses with, in some cases, a beautiful sheen of iridescent colours. These stalactites usually have the appearance both externally and internally, when broken across, of being composed entirely of brown hæmatite, but on placing solid pieces of them in hydrochloric acid the iron oxide dissolves and most of them leave a more or less complete skeleton or inner framework of silica. Some of the smaller stalactites after such treatment appear as if made of transparent gelatine, from the silica being left in the colourless and gelatinous condition. The gold present seems to be much more intimately connected or associated with the silica than with the hæmatite. The hæmatite and quartz appear in some cases as if they had been in part deposited simultaneously, but in many other instances the hæmatite forms the external coating and therefore is the last or most recently deposited.

In some of the massive specimens of hæmatite there are distinct veins and strings of ordinary quartz; such masses when acted upon by hydrochloric acid leave a more or less cellular or porous non-gelatinous residue of quartz not unlike certain varieties of geyserite or siliceous sinter deposited by hot springs, but the specific gravity is 2.55, and the hardness 7 and no combined water seems to be present, hence the mineral possesses the properties of ordinary quartz rather than those of sinter. Some of the quartz looks as if it had originally been charged with iron pyrites which has since been converted into oxide of iron, (such a mixture when occurring at the outcrop of a lode is usually termed gossan); the oxide has in parts been subsequently removed leaving a spongy siliceous skeleton.

Mr. R. L. Jack, F.G.S., Government Geologist, Queensland, has carefully examined and described the Mount Morgan deposit and attributes it to geysir action, but the specimens examined by me may have come from a part having a different origin, and as I have not visited the locality, I am unable to express an opinion upon the main question.

MAGNETITE.

In the form of a massive, imperfect crystal, but with some of the faces well marked; possesses but slight magnetic properties. Brown outside giving it the appearance of brown hæmatite. Weight 195.303 grammes, the sp. gr. at 18° C. was found to be 4.93. Near Cowna Station, Barrier Ranges.

MOLYBDENITE—Molybdenum di-sulphide.

In the form of large lamellar plates most of which show two to four edges of a hexagon. Some of the masses are nearly three inches thick, and as much as $3\frac{1}{2}$ inches across and $5\frac{1}{2}$ inches long, with extremely well marked cleavage, hence, very thin sheets, with most brilliant lustre, of nearly 15 inches superficial area can readily be obtained.

Quite recently some beautiful groups of almost perfect crystals have been brought from the same locality, *i.e.*, Kingsgate, near Glen Innes.

QUARTZ—Cellular or Porous.

Mount Morgan, Queensland. This has very much the porous and cellular appearance of the silica deposited from hot springs, and has accordingly been described as Geyserite by Mr. R. L. Jack, F.G.S., Government Geologist for Queensland. Reference is made to this under Hematite, p. 236.

More or less cavernous specimens of quartz are met with in the New Reform Mine, Lucknow, and are known to the miners as "Lode clinker." These are of a dull brown and earthy appearance externally, and are evidently pseudomorphous after calcite.

REDRUTHITE—Grey Copper Sulphide.

Occurs with crystallized azurite, malachite and silver chloride in the Broken Hill Proprietary Company's Mine.

RUTILE.

Acicular hair-brown crystals of this mineral are met with in quartz at Tingha. Mr. D. A. Porter of Tamworth has had some specimens cut and polished with good effect.

SIDERITE—Iron Carbonate.

Obtained from vugs in the Umberumberka Mine. The specimen is built up of plates forming cavities, in some cases almost cubical and in others more or less rhombohedral, and varying in size from one eighth to one inch or so across. On the walls of these cavities are scattered small but well formed crystals of anglesite (lead sulphate); the black colour is apparently due to some galena and perhaps zinc blende.

When powdered the mineral effervesces slightly with cold hydrochloric acid and evolves sulphuretted hydrogen, and on qualitative analysis was found to consist essentially of carbonate of iron and zinc with small quantities of blende, manganese, lead, and traces of silica and lime.

SILVER—Native.

The native silver occurs scattered through (vein) quartz in exceedingly thin and minute flakes looking more like mica than silver. In one specimen the silver is associated with minute garnets; silver chloride, silver sulphide and lead carbonate are also associated with the native silver. From Silvertown.

SILVER CHLORIDE.

From the Broken Hill Proprietary Company's Mine. In cubes about $\frac{1}{16}$ " through, with the angles replaced by faces of the octohedron; these are accompanied by octohedra and combinations of the octohedron and cube in which the faces of the former are predominant or more largely developed. Twin crystals of the octohedron are also found. Most of the crystals are very irregularly developed and as usual the edges are generally rounded and the faces slightly hollow or cavernous.

The crystals are sometimes seated on a clay-like material, on stalactitic black oxide of manganese, hæmatite, cerussite &c., and diffused through white kaolin.

Most of the specimens when fresh are pale shades of grey or green, but they soon darken on exposure to light.

One specimen from Broken Hill, in galena, shows the silver chloride concentrated in the central parts of the mass of galena; Mr. Marsh points out that it probably represents a stage in the formation of the slugs or nuggets of horn silver. Further concentration and the removal of the outer crust of galena would of course leave a core of silver chloride.

The crystals are sometimes scattered singly or in small groups, and very often are arranged in branching and arborescent forms and occasionally they can be separated from the matrix in irregular layers looking like lace work.

The largest crystals placed before you are about $\frac{3}{16}$ " in thickness, but such large crystals are as usual very badly defined.

In many cases the silver chloride looks more like a sublimate than a crystallised deposit from solution.

The silver chloride occurs also in a pure white kaolin in irregular strings and branches ; when the mass is cut through the kaolin presents a beautiful marbled appearance, from the green veins, strings and points of silver chloride being irregularly spread over a dead white ground ; after exposure to the light for a time the veins and markings, of course, become black.

SILVER SULPHIDE—Argentite.

In small particles scattered through vein quartz ; associated with it is a little iron pyrites and iron sesquioxide. No crystals of argentite could be detected.

Locality—Wollombi, thirty miles from Armidale. Collected by Mr. J. M. Smith of Sydney.

The second specimen is from the Day Dream district. Massive of about 6 oz. in weight, weathered externally and coated in part with mica.

STAUROLITE.

In a black mica schist with crystals of common garnet, from about two miles north of the Acacia Dam, Broken Hill. Mr. Marsh states that the schist stands up in narrow bands above the associated rocks on account of its being less rapidly weathered.

The staurolite crystals are in twin groups in the form of St. Andrew's cross, and vary from $\frac{1}{4}$ " to $\frac{1}{2}$ " in thickness and up to $\frac{2}{3}$ " long. These are much larger than those previously described.*

TOURMALINE.

From the quarries in granite, about three miles east of Silverton. An irregular fragment of a large crystal of tourmaline, about one and a half inches through and two inches long ; the broader end of the crystal has a quartz core.

ZINC CARBONATE.

From Broken Hill Proprietary Company's Mine. In the form of small, colourless complete scalenohedrons or dog's tooth crystals, slightly curved. Surfaces somewhat rough, about $\frac{3}{16}$ " long by $\frac{1}{16}$ " through, very uniform in size. Perfect rhombohedral cleavage.

* Liversidge, Minerals of N.S. Wales, 1888, p. 181.

The crystals are seated on stalactitic ferruginous black oxide of manganese.

ZOISITE.

The specimen was obtained by Mr. D. A. Porter from Upper Bingera.

SOME FOLK-SONGS AND MYTHS FROM SAMOA.

Translated by the Rev. G. PRATT.

With Introductions and Notes by JOHN FRASER, LL.D.

[*Read before the Royal Society of N.S. Wales, December 2, 1891.*]

XXIV.—IA ‘ALO-‘ALO, LE ALO O LE LA—A ‘Tala.’

‘*About ‘Alo-‘alo, the son of the Sun.*’

INTRODUCTION.—At all times and in all places, men have believed in luck, fortune, fate, destiny. The ancient Aramaeans, in Isaiah’s time and before that (Is. lxxv., 11), used to “prepare a table for Gad and fill up mixed drink for Meni,” and their successors, the modern Arabs, still call Jupiter and Venus “the stars of the greater and the lesser Fortune,” while Mars and Saturn are to them “unlucky stars.” The ancient Greeks and Romans had their Moirai and Parcae—deities whom the great Jove himself could not move from their purpose; the Roman poets often speak of “ineluctabile Fatum” and of “Fortuna laeta saevo negotio, nunc mihi, nunc alii benigna”; the modern Turks are firm believers in fate, ‘kismet’; in our language, too, luck is a well-known word and has established itself in daily converse; for, to-day, we say of a friend, “he is a lucky dog”; to-morrow, perhaps, we find him “down on his luck”; sometimes we think that there is “luck in odd numbers,” and again that “Friday is an unlucky day” for beginning an enterprise.

All these beliefs have arisen from man’s experience in life; he cannot see why a labour which has been undertaken and faithfully carried on comes to failure, while another of an exactly similar nature and in similar circumstances has been successful, although small pains were bestowed

upon it; he observes that one worthy man is covered with disaster, while another, not half so worthy, is successful in everything. And so, out of these problems of daily life, comes the doctrine of fate and luck,—blind to merit, inexorable and capricious in the affairs of men.

The Romans were keen worshippers of Fortune, who seems to have been viewed as propitious aspects of the Sun and the Moon. And many other Aryan nations have shared in this view; even we, of the English tongue, often say, "Happy is the bride that the sun shines on," and, on seeing the new moon for the first time in any month, many of us, either playfully or in earnest, will turn the silver coin in our pocket.

The present myth is Aryan in this respect that it associates Prosperity with the Sun; for, in it, 'Alo-'alo, 'Sunbeam,' goes up to the domain of Darkness and Daylight, where the Sun lives, to get the "hook of Prosperity." As with the golden casket in "The Merchant of Venice," so here; the hook of Calamity is the more tempting article to the eye, but the wise youth, previously instructed thereto, makes his choice according to the advice of those who know, and thus becomes the happy possessor of a hook which has such power over the fishes of the deep that they will come to it in shoals to be caught. But his possession of it is not secured to him until he shall have reached his home in Fiji; on the way he carries the hook at his back, slung there by a string round his neck; all the way home he must not attempt to look at the hook; but, alas! as he approaches the boat-opening and is almost home, curiosity becomes too strong, lust for the forbidden overpowers him; he brings the hook round in front to see it; it pricks his neck; he dies at once and falls down into the bottom of the sea. How like this is to the Grecian story of Orpheus and Eurydice! That incomparable musician loses his wife, who is carried off to Hades; lyre in hand, Orpheus goes down to seek her; his music charms even the hard heart of the Queen of the Shades, and Eurydice may follow him to the upper world and to life and light again, but he must not look back as they ascend. The way was long; just as a faint glimmer of daylight was within reach of his eye, he looked back, and—Eurydice vanished for ever from his view. And so also on the same lines are other myths drawn, all the world over.

Then again, in our myth, to be successful in fishing, the hook must be fastened on to the line with a punctilious observance of all due rites. There are three brothers who try, but it is only the youngest of these, small and despised by the others, that succeeds. Here we have a counterpart to the nursery tale of Cinderella and many similar stories.

Tala.—1. 'Alo-'alo, the son of the Sun, dwelt with his mother named Manga-manga-i-fatua, 'branching-stone,' at a place in Fiji, but there were no other inhabitants at that spot. When grown up to manhood, he took to wife Sina, the daughter of Tui-Fiti. When she was near her confinement, Tui-Fiti, her father, said to her, 'Who are the parents of your husband? Go and get some present from them.'

2. Sina told her husband what her father had said. He immediately went to his mother Manga-manga-i-fatua, and asked her who his father was. 'I am ridiculed,' said he; 'it is asked of me, Who is your mother, who is your father?' His mother answered 'Come now; the Sun is your father; he is the son of Po and Ao; we have here nothing to give; but go thou to Po and Ao; they possess two articles of value, *'o le 'au o Manū ma le 'au o Mala*, 'the hook of Prosperity and the hook of Calamity'; the *'au o Mala* hangs at the end of their house; don't you take that; but go to the corner; there hangs *le 'au o Manū*; take that; Po and Ao do not allow any strangers in their house; but, when they see a stranger approaching, they suddenly let down the roof of their house so that the eaves rest on the ground.'

3. Thus instructed, 'Alo-'alo directed his course to the heavens. When he drew near the house of Po and Ao, the roof was suddenly lowered, but he stood till it was raised again. On seeing him standing there, they asked who he was. He answered, 'I am 'Alo-'alo, the son of the Sun.' On hearing this, they welcomed him, and bade him come in, and embraced him, and wept over him, and said that they did not know that he was the child of their son. He then told them the particulars of his family relationship and the errand on which he had come, stating that Tui-Fiti had scornfully asked who his parents were. They answered that they had only two articles of property of any value, *'o le 'au o Manū ma le 'au o Mala*, and that he might take whichever of these he pleased. Following his mother's instructions, he passed by the more attractive object, which was hanging in the end of the house, and he took the *'au o Manū* and hung it round his

neck. Po and Ao then charged him strictly not to look at it till he got to his family again, but to let it hang at his back, and not to look behind him all the way home. As he was leaving the house, his father's sister, Sina, called after him, and begged him to attend to the instructions which had just been given to him—not to look at the thing till he got home. He descended from the sky and pursued his way over the ocean, repressing his desire to inspect his property, till he got opposite to the entrance to the landing at Fiji. The hook, which had all this time been hanging on his neck at his back, he now drew to the front ; it immediately wounded his neck, and he fell dead down to the bottom of the sea.

4. It was afternoon when Tui-Fiti asked where 'Alo-'alo was. His wife said that she did not know ; perhaps he was gone to seek something from his mother. On this, a young man went out and saw a great congregation of fishes and birds in the entrance of the boat harbour. Tui-Fiti sent him out to see what was the cause. He went, looked down, and there he saw the body of 'Alo-'alo, with the *'au o Manū* about his neck. He drove away the fishes, dived in, and brought up the body and the hook. 'Alo-'alo was dead, but Tui-Fiti was very much pleased with the hook. Tui-Fiti then directed his family to prepare food and seek out an able sailor to test the value of the hook. The hook was entrusted to the care of a *tautai va'a-alo*, 'a fisherman and boat-steerer of the 'bonito' canoe,' named La-ulu, and his wife's name was Fau-mea. They had four children, three sons and one daughter, named respectively 'O-A'au-pini-pini, 'O Mo'e-ulu-galu-iti-iti and Mo'e-ulu-galu-tele. The girl's name was Sina-te'e-alofa. But the Tutuila people give the boys' names as Aa'u-pini-pini, Aa'u-tele and Aa'u-iti-iti.

5. The fisherman, La-ulu, knew that the hook must be properly fastened to the line, for on this would depend their success in fishing. So he got his sons to try their skill on it. A'au-pini-pini tried first. While he was fastening it on, some rats, '*tilo-tilo*,' came peeping, with a desire to carry off the hook ; so they nibbled at the string and dragged it about. When the hook was fastened

on and ready for the fishing, they saw that it would not prosper, for it was fastened on wrongly ; so they went and reported this to a fresh-water fish called *le sesele*; the *sesele* went and reported to another fresh-water fish nearer the sea, called the '*ava-ava*'; the '*ava-ava*' reported to a young '*bonito*,' called the *tava-tava*, which keeps near the entrance through the reef ; the *tava-tava* went and reported to the *atu*, 'the bonito' fishes, [saying] that they need not be alarmed, for that the hook was wrongly fastened.

6. So the fleet of canoes made ready for the fishing and went out with the hook *o Manū*; they paddled about among the '*bonito*,' but none would bite ; so the canoes returned to land. Then were the family of the fisherman in great dread of the wrath of Tui-Fiti. The other brother now tried, whose name was Mo'e-ulu-galu-tele. He too failed from the same cause ; and again the mice went and reported the failure, as before, which was duly made known to the '*bonito*.' Again they went out to catch '*bonito*,' but in vain ; so they returned to land. The family were greatly distressed, saying, 'We shall be killed.' So they begged their sister to try her hand at the fastening of the hook. She refused, saying, 'When did a woman ever undertake to do such a work.' But she begged them to let their little brother, Mo'e-ulu-galu-iti-iti, try it ; and, if he failed, why then, they must all die together. They answered, 'What does that little fellow know ? how can he hit the right way ? you try.' She, however, urged them, saying, 'Call Mo'e-ulu-galu-iti-iti ; let him tie on the '*au o Manū*.' They then called him, and ordered him to make haste about it. The lad answered, 'Oh ! but I have not bathed yet.' They kept on calling and urging him to be quick, but Sina-te'e-alofa interposed and begged them not to hurry the lad. He went and bathed ; then came and dressed himself in his best garments, and asked his sister to give him one of her finest sleeping mats to sit upon. His brothers came in and saw him sitting on the best mat ; they said, 'Oh ! is this thing sitting upon Sina's bed ?' The boy, however, continued to sit upon the clean mat, arranged the hook and line properly, and completed the task. The mice saw that the hook

was rightly fastened on ; so they went and reported the fact to *sesele*, saying that the '*au o Manū*' was properly adjusted. The report was then carried to the others, as before.

7. La-ulu now went out with his sons to catch 'bonito.' The very first day, their success was very great ; they came in with a boat-load. But this success only made him anxious to keep the hook for himself ; he therefore hid the hook in the ground, and came and told Tui-Fiti that the line had broken and the hook was carried away. Tui-Fiti doubted this. Looking out to sea, he saw that the 'bonito' fishes were jumping out of the water and diving again straight down. From this he conjectured the truth, and sent an order to La-ulu to dig up the hook and go a-fishing. He did so, and was as successful as before. But he still coveted the hook, and again he said that it was carried away. This time, however, he had taken it up into a cocoa-nut tree and hung it there. Tui-Fiti again saw the 'bonito' fishes jumping straight up from the sea, with their mouths open ; so he immediately sent an order that the man should take down the hook and go a-fishing. He went and was successful as before. Again he tried to appropriate the hook, but this time he wrapped it securely in some old cloth. Tui-Fiti, again suspecting deception, sent a servant out to sea to observe which way the 'bonito' were going ; if they went out seaward through the boat-opening in various directions, then it was true that the hook had been carried off ; but if they came straight inland, that was a sign that La-ulu had concealed the hook. He thence divined that the hook was wrapped up ; so he sent a messenger to La-ulu, ordering him to take it out of the cloth and go a-fishing. He obeyed, went out, and was successful as usual.

8. Now La-ulu resolved to run off with the hook, taking with him his whole family. Accordingly, he, his wife, and his four children set out on a swimming expedition to find a home wherever they could. They were drifted to the neighbourhood of Manu'a, but could not get ashore there ; so they drifted farther, to the south side of Savai'i. The parents then said that they

could swim no more, and that they would drown there with Aa'u-pini-pini and become sunken reefs, where the survivors might come and fish. 'We,' said they, 'will become reefs here; do you come with your canoes and fish here; come with the people also among whom you may settle; we give you the hook to do with it as you like.' They then sank and became reefs. The others landed at a place called Lavania. The chief of the place was of that name, and Sina-te'e-alofa became his wife. Here they proceeded to prepare their hook for fishing, but, failing to observe the necessary rules, it was at first wrongly fastened. Mo'e-ulu-galu-iti-iti at length did it properly, and so he and his brother were very prosperous in their fishing.

9. In due time, Sina-te'e-alofa gave birth to a child, whom she named Imoa-sala-ta'i. One day, her father and mother went into the bush to get wood for a house or a canoe; the child followed, but missed them and lost her way. In vain did they search for her; as she was not to be found, they made funeral rites for her. She, however, was not dead, but had wandered far inland to a place inhabited by an *aitu*, that is, a spirit in human form, named Afi'a. With him she dwelt and became his wife. She gave birth to a son, whom she named Tau-tunu, 'continually roasting,' because that, when pregnant, she had longed for and eaten the *ufi-tauyam*, which is always roasted.

10. When he was grown to be a big boy, he went to swim in the river. He was carried by the stream down to the sea, abreast of the spot where the canoe of his mother's uncles was lying. Here he got ashore, and went and hid himself in the bows of the canoe, that is, under the covered deck in front. Soon the brothers came, launched their canoe, and went out to fish. There was plenty of fish, but the fish would not bite. The steersman said to his brother, 'Look into the bows under the deck, and see what is there to cause our ill luck.' He looked and, behold! a *tangata*. They commenced beating him. The boy cried out, 'O Imoa-sala-ta'i, O Imoa-sala-ta'i-te'e-alofa, I shall die.' Hearing him call out their niece's name, they asked who he was. He answered, 'The

child of Imoa-sala-ta'i.' They were much affected on hearing of their lost relative, and wished to take the boy to his mother, Sinate'e-alofa. They then went with him inland to find his parents. When his father, Afi'a, saw them approaching, he ran away, frightened by the sight of human beings. The delight of the brothers was great at having found the long lost Imoa-sala-ta'i; and they begged her to go back with them and no longer dwell in the bush. She went to call her husband, but he was ashamed at first to come near and afraid; when at last he did come, he came crouching behind his wife. The brothers then begged them to leave the bush and go to live with them at the seaside. But Afi'a objected. At last he said, 'Well, you go on first, and I will come down in the evening.' In the evening he went down and partook of a meal with them, but returned with his wife to the bush at early dawn.

11. Thus things continued to be for some time. At last, as his wife wished to live with her relatives, and he still objected, he said, 'Well, you go down and live with them, but don't forget Afi'a in his bush; and if you get a portion from them, divide it and put aside a part for yourself and a part for me; do the same with any *tonga*, you may get.' Thenceforth she strictly observed this injunction, and when ever she got food she divided it saying, "This is for me, that is for Afi'a; so also with the '*tonga*'; [hence this song]:—

Ua se le Imoa-sala-ta'i	It is an Imoa-sala-ta'i
I tuā vao a Savai'i;	In the back bush of Savai'i;
Ua se le Imoa-mā ē	It is an Imoa-ma
I le lafalafa o Amoa;	In the flat lands of Amoa;
Tau-tunu lou tausī pā;	Tau-tunu is thy hook-keeper;
Na iloa i vao lou tina;	Thy mother was found in the bush;
Tau-tunu o le pele Afi'a;	Tau-tunu is the beloved of Afi'a;
Na iloa ma galo-vao-ina.	He was known as "forgotten in the bush."

O!

O!

12. Tau-tunu remained with his mother and her family, and eventually the '*au o Manū*' was given to his care. He then took it about to several places; and, wherever he went, success went with him. Eventually he came to Manu'a. He landed at Tā-

fanga-fanga in the space between Maefu and Lavania ; there is still the rock called the 'Bamboo-pillar' (Po-ofi)—the rock in which the end of the bamboo fishing-rod was inserted ; for a strong bamboo is used as a rod in fishing for 'bonito.' He took up his abode with Pule, the chief of that place, and got the chief's daughter to wife ; her name was Sina.

13. Tau-tunu was now old and ugly, but he had the power of renewing his youth and assuming again a handsome appearance. He used to give strict charge to his wife how to conduct herself when he went a-fishing. 'Don't draw up the mat-sides of the house,' said he ; 'don't clear away the rubbish ; don't bathe ; lest the 'bonito' should refuse to bite.' She, however, went and bathed and decorated herself with turmeric ; and then went down to see him fishing. She was surprised at his ugliness, for she had never so seen him before ; he had always before appeared handsome. Now, she had with her a basket to put the fish in. He called to her not to touch the fish or the hook. She, however, handled the hook and made it yellow with her turmeric. He was very angry, took up the bamboo, and gave her a severe beating with it, and left her. She followed him, begging him to remain, but he went off and came to Siu-fanga at Taū, and took up his abode for a while with Sio of that place. Sio had two daughters, Manu-ola the elder and Mana the younger ; &c., &c. [*Here the story breaks off.*]

NOTES TO No. XXIV.

INTRO.—*The Stars* ; the whole system of the astrology of the Babylonians was founded on the belief that the prominent stars represented divinities, propitious or adverse, who had control over the affairs of men ; similar beliefs prevailed everywhere in the ancient world, and the more modern astrology was a tradition from these *Moirai and Parcae* ; the connection of the name *Moirai* with the *Gr. meiomai* 'I share,' and *meros*, 'a part,' suggests that *Parcae* is from the same root as Lat. *pars* and *partior*—a root which is widely spread not only in the Aryan but also in the Shemitic languages.

Saevo negotio ; our own poet Spenser says—

Fortune all in equal launce doth sway
And of mortal miseries doth make her play.

Worshippers of Fortune; cf. "Cæsar and his fortune." The Romans had both a 'Deus Fortunus' and a 'Dea Fortuna.'

Power over the fishes; the islanders have many superstitious notions as to success in fishing.

Last for the forbidden; "nitimur in vetitum semper, cupimusque negata."

PAR. 1. *Branching-stone*; in the 'Story of Creation' (No. XXX.), Papa-'amu-'amu, 'the branching-coral-rock,' and his children, are among the earliest of created things.

Tui-Fiti; 'king of Fiji'; in all these tales, Fiji is to the Samoan mind a far-off land of mystery, much in the same way as British tales speak of 'China' or the 'world's end.'

Some present; presents are given to the wife's family on the approach of child-birth; these are called *fa'amau manáva*.

2. *He went to his mother*; 'the Sun is your father'; cf. the classic story of Phaethon (= 'Alo-'alo) and father Sol. A similar disaster overtook both of these youths.

Po and Ao; see the 'Story of Creation,' par. 21.

The eaves rest on the ground; this doubtless means the clouds and mists which sometimes come down on the earth and cover it. In the Hebrew cosmogony, the clouds are over the earth, like a canopy or tent which may be let down.

(*Foreign*) *articles of value*; 'oloa.'

3. *Son of the Sun*; the common Samoan word for 'son' is *atali'i*; the word here is *alo*, a chief's word; the use of it indicates that by birth this young man was a person of rank.

4. *Fishes and birds*; attracted by the potent charm of the hook, though now submerged; magic is superior to the powers of nature.

Boat-harbour; *boat-opening*; a narrow passage through the encircling reef, fit only for boats.

Tautai va'a-alo; 'tautai' is a 'sailor-steersman,' and 'va'a' is a 'canoe.'

His wife's name, &c.; details of this kind are all-important in the eyes of a Samoan.

La-ulu; this is a common Samoan name, 'branch of bread fruit.'

Fau-mea, means 'to tie-together things'; the component parts of the other names are:—*a'au*, 'reef'; *iti*, 'small'; *tele*, 'large'; *mo'e*, 'sleep'; *ulu*, 'head'; *galu*, 'wave'; *te'e*, 'to be haughty, to reject, to resist'; *alófa*, 'love.'

Something; i.e., *tonga*, 'property'; 'nothing' in par. 2 is 'no *tonga*.'

Much pleased with the hook; 'na *fiafia* i le Manu.'

5. *Rats, mice*; folk-lore knows a good deal about them; there is a native rat (*imoa*) in the islands.

Fastened wrongly; 'ua *fau sala*.'

Need not be alarmed; *alili*, 'take it easy'; 'there is no danger.'

6. *That little fellow*; they despised him, and so also was Cinderella despised by her sisters.

Sina's bed; the fine sleeping-mats are the bed.

7. *Jumping out of the water*, as if eager for the hook.

9. *Imoa-salatai*, 'the nibbling rat.'

Funeral rites; for a great chief, the people sing an extemporised hymn of praise and keep fires burning before his house.

10. *Tangata*, 'a human being'; the Samoan word—*tagata* (= *kanaka*)—means 'man, mankind.'

'*O Imoa, &c.*; he combines his mother's name with his own.

In the evening; an 'aitu,' like a ghost, does not care to be seen in daylight.

11. *Don't forget Afi'a in his bush*; 'auā ne'i galo a'e Afi'a i lona vao'; the story about Afi'a is so well known to the people that this phrase has established itself in the language as a common proverb; when Mr. Pratt was finally leaving Samoa, the natives used it in their farewells to him.

Tonga; 'native property' as above, i.e., mats and other things.

This is for me, &c.; 'si 'au mea sia; si mea a Afi'a lea; si a'u mea sia; se toga a Afi'a lea.'

Imoa-ma; 'white rat.'

12. *In the space between*; 'i le va.'

13. *Renewing his youth*; a common power in fairy tales.

Don't open the mat-sides; 'auā le pu pola'; the 'pola' are plaited cocoa-nut-leaf mats, which, as in our tents, are used as flaps to enclose the lower sides of a Samoan house.

Turmeric; much used in the toilet of women and girls in Samoa. The plant grows wild there, and the making of the powder is a common household industry.

The story breaks off; like the *Arabian Nights*, this story about the hooks admit of great expansion and has numerous 'recensions,' long and short.

XXV.—'O 'ALO-'ALO—A 'Solo.'

'*Sun-beam,*' the son of the Sun.

1. 'Alo-'alo went to make it known to his parents,
2. That Sina [his wife] is with child.
3. ['Alo-'alo], the child of Manga-manga-i-fatua
4. Sought in the heavens for his parents.
5. He looked for them in the first heavens,
6. Where were the images of Po and Ao;
7. And the house had spears for its eaves.

8. 'But, [said his mother,] when your errand is done, come[back];
9. 'Alo-'alo, when you enter [the heavenly house],
10. The hook of adversity, take care to give it the go-by ;
11. The hook of prosperity, bring it [with you].'
12. His companions are the forked lightnings.
13. Sina [his aunt] there follows him and beckons :—
14. 'Alo-'alo, [she says,] wait; let us two say good-bye ;
15. When you are going away, don't look back ;
16. Don't you take off the tabu from the sea ;
17. The hook of prosperity is sharp.'
18. [But] 'Alo-'alo neglected her parting command.
19. He was wounded to death because the tabu was taken off.

He dies.

20. Weeps the Sun on his mountains in the sky ;
21. Alas ! 'Alo-'alo is killed.
22. Fiti comes down, and sets the fish-trap.
23. 'Alo-'alo lies far down in the opening of the reef.
24. The fishes of the deep come inside the reef
25. To the hook of thy son, O Sina.
26. 'Let a [skilful] fisherman be sought out for Tui-Fiti ;
27. That the plaited string may be fastened aright [to the hook].'
28. Ulu-galu-iti-iti was prospered [in this],
29. But Aa'u-pini-pini was unsuccessful. [sea ;
30. The two [parents] arose, swam together, and perished in the
31. The sister got to land ;
32. She gave the hook to Savai'i.
33. [Brother, said she,] 'long have we sought for thee ;
34. Now prepare to fasten the hook'; [but] it went wrong
35. Because he was dressed in his girdle,
36. And sat on a 'tapa-au' mat when he fastened it, not on a 'fala.'
37. The 'sesele' reported it first to the shore,
38. And gave an account of it to the 'tava-tava.'
39. Sleep on, 'bonito'; do not wake;
40. They are paddling out and the hook is wrongly fastened ;
41. The wrongly-fastened-hook paddles in vain.

42. Sina-te'e-alofa then said,
 43. 'O Mo'e-ulu-galu-iti-iti, be thou skilful [to fasten it];
 44. By-and-by we perish by the wrath of Tui-Fiti,
 45. [For,] by-and-by, we shall not get [any fish];
 46. [So] Mo'e-ulu-galu tied it [rightly].
 47. The 'popolu' goes first into the sea;
 48. The 'avi'i' uttered a curse on the report,
 49. For the fastening of the hook is right,
 50. And prosperity will now come in heaps.
 51. The fleet prepared to go a-fishing,
 52. [For] the hook of prosperity was [properly] fastened.
 53. The mother-of-pearl hooks,—the hook of Calamity
 54. And the hook of Prosperity—
 55. Were carried into the middle of the round end of the house,
 56. And were hung up there.

O !

NOTES TO NO. XXV.

- Line 1. 'Alo-'alo; the story is the same as in the previous prose version.
 5. *First heavens*; see the 'Story of Creation,' par. 21.
 7. *Spears*; these are the sunbeams; cf. 'the far-darting Apollo.'
 8. *Errand*; lit., 'your parting,' i.e., 'when you have done your good-bye.'
 12. *His companions*; this line seems to me to say that 'Alo-'alo ascends to the palace of Po and Ao in the region of the lightnings.
 13. *Beckons*; 'tapatai,' to make signs with the hand.
 15. *Don't look back*; that brings ill luck also when men are going a-fishing.
 16. *Tabu*; anything is 'tabu' when it is set apart to some particular use. A fruit-tree or anything else can be 'tabu'-ed by a native by fixing on it some sign of 'tabu'; then no one else will touch it. The meaning in this line seems to be, that, as the sea is a natural fishing-ground and devoted to that, 'Alo-'alo, by looking back, would destroy that use of it, so far as this hook was concerned.
 17. *Sharp*; fe'ai, 'fierce.'
 19. *He was wounded*; disobedience is at once avenged.
 27. *Plaited string*; 'fau fatuā.'
 35. *His girdle*; this was the common every day 'lava-lava.'
 36. *The tapa-au* is a common mat of cocoa-nut leaf; *the fala* is a fine mat of pandanus leaf, for sleeping on.

45. *We shall not get*; the meaning of this line is doubtful; the words are—‘tatou le o’o.’

55, 56. The lines are:—55. ‘Ua sulu-sulu i le matuā tala.’ 56. ‘O aala i le matuā tala.’ Their meaning is doubtful; either they refer to the place of the hooks in the palace of Po and Ao originally; or they may mean that the hook of Prosperity, after the successful fishing, was hung up in honour in the house of Tui-Fiti.

XXVI.—PILI, ‘THE LIZARD’—A ‘Tala.’

How the island of Upólu came to be divided into districts.

1. Penga and Penga were a pair that dwelt in the Fanga district of Fiti-uta; Pili-mo’e-langi, ‘the lizard that sleeps in the heavens,’ and Pili-mo’e-vai, ‘the lizard that sleeps in the fresh water,’ were born there, together with Sina—three brothers. Pili-mo’e-langi was taken up into the heavens, but the Pili-mo’e-vai was put in the water, and remained there; and Sina lived with her parents; thus they dwelt as a family. It happened on another day that the parents went out to work, but Sina remained in the house. The parents left her a command, ‘Don’t go outside; also don’t go to draw water [from the well], but sit still in the house; don’t lift up the mat-flaps of the house.’ But the girl did not obey; she went to the well to draw water, when her parents were gone to work. Then the girl was caught by the fish; that was her brother, Pili-mo’e-vai. Then Sina shouted; as she passed along, she cried to her parents in the place where they were working. The fish followed her; but again the girl ran away, because she did not desire to look on the fish. She ran far away to Aua-luma, and there she married Pule-le-‘i‘ite, ‘Pule-the-prophet.’ Pule received her and she dwelt with him. But the fish still followed her; he made his abode in the water at Vai-lenga, ‘yellow water.’ The children of Pule made ready to draw water, and Sina went with them. Pule said, ‘Sina, there are chiefs down below’ (for the fish was still in the water); but Sina did not obey, for she went and bathed. Then the fish got her again; she ran away, crying as she went. Then Pule said, ‘Did I not tell you that there were chiefs down below; but you did not obey me.’

The fish followed her into the house. Then Pili prepared a way for the fish ; he spread a path with good things for the fish to come on ; but the fish came on one side ; and sat in the front part of the house of Pule. Then Pule said, 'You are come ; there is Sina sitting there.' Now Sina was pregnant by the fish. Then Pili said (that was the name of the fish), 'O Pule-*'i*ite, thanks for your offer, and that you have shown respect to me ; come now, I give up the woman to you ; if she bring forth a boy, let me be named in the child ; you shall call it Pili ; but if a girl, I leave it to you ; you will live together as a family ; but I will go.' Then the fish went away and Sina dwelt with Pule. It came to pass that she brought forth a boy, and he was called Pili, as Pili had enjoined.

2. The child grew up ; then he went to the beach on to the rocks to look at the sea ; and he turned his gaze to see whether any fish remained in the boat-opening ; then a desire for fishing took hold on him. So he went to his parents to ask them to make him a net ; and they made it ; the net was finished. Then he bade them make things to tie up the net with ; and he said to his parents that they should broil three birds, but not take the entrails out of the birds ; and prepare them well ; and then sit down and wish luck to the fishing. Then she went down towards the beach to Vai-lenga to procure stone sinkers for the fishing. Thus the parents prepared all things that Pili had enjoined. Then Pili said, 'Come now, bring your things.' They gave them up. Then Pili said, 'Where are the entrails of the birds ?' His mother said, 'There are none ; I have eaten them.' Then Pili said, 'Did I not tell you to do it well ? what about the respect to be shown to the fishing.' Then Pili said, 'Bring these birds' ; and she brought them ; he took the birds, but the mother had bitten off the parson's nose from one of them.

3. Pili was grieved, and said to his mother, 'Take these your things and eat them, for you desired them ; I will go.' He went away in anger. Then he was overtaken by the night at Fa'alava, 'cross-roads,' and he entered into the house of Tui-Taū and

slept there. The morning dawned, and he went to a land called To'a. Then he rested on the sandy beach and untied the sinkers of his net; so it was called Fanga-maene, 'the beach of the sinkers,' but it is called now-a-days, Fa'a-samene. Then he went and jumped to Muli-nu'u, 'land's-end'; thence he swam, but he was doubtless carried away by the current, for he came to land at Pola in Tutuila. Then he reached Vatia and stayed there many nights; he worked; great were his plantations; he built a house; and cleared the swamp in that land, and worked it, and his work was prospered.

4. Then the chief of Vatia wished to give a name to Pili, in order that he might sit in the circle of chiefs, and stay with them and serve. The name with which he was to sit in the circle was Suama-le-vai-fanua, 'Ploughing-up the swamp-land.' Then Pili had a contention with him, for he did not want that name; although he was able to act as a servant to the chiefs. So he contended with the chief, but Pili was worsted; therefore the name remained with him—and he was called 'Suama-vai-fanua.' Now the day of the circle of the chiefs came on, and the people of the land went to get food for the circle of chiefs. Then they asked Pili, 'Where is the food for the journey'? And he pointed it out to them all. They asked him again, 'Where is the food'? Then he showed it to them. They asked him again, 'Where is the fire-rake'? Then he showed it to them. When they had finished raking the oven, they asked again, 'Where are the tongs'? Then Pili was vexed; he said to them, 'Did I not say I am not able to serve you; take back the name; I am going.' Then he went away and came to a deserted land; he undid the floats at that place, and so that place was called Auto, 'floats.' Then Pili went and swam in the sea of Upólu; he was carried away by the current and did not reach Upólu; but he went to the sea of Savai'i, and reached Aopo and Asau, in the land of Tui-Aopo and Tui-Asau. Then he dwelt there and worked; his plantations reached to the highest back-ridge of Savai'i; great was the success of his work in that land, and he had much food. Then he stayed

there many nights. Doubtless on account of his great work, he was called there Pili-opo, but Pili was his name when he left Manu'a.

5. Then went a courting-party to Fasito'o, to the daughter of Tavae-tele, 'the great frigate-bird'; Pili's proposal was accepted by the lady; they were married; then they had four children—Tua and Tua-ile-Asanga and Tua-ile-Ana and Tolu-nga-fale. Then Pili made his distribution [of lands] amongst his children, thus:—'You, Tua, you will go to the eastern end of the land; you shall remain there permanently; your appointment is the planting-stick ('oso'), from which you will get your food; and be prosperous.' That is Atua. [To the next he said,] 'You are Tua-ile-Asanga; you shall dwell in the middle of the land; that is your appointment; by a strong arm you shall overcome.' That is Tua-masanga. 'You, Tua-ile-Ana, you shall dwell in the east of the land; you shall look towards Savai'i; your appointment is the war-club; it is for you to receive Savai'i as guests.' That is A'ana. 'But you, Tolu-nga-fale, shall dwell in Asanga; you shall look and observe.' That is Manono.

These are the children of Pili, by which Upólu was divided; each one dwelt there separately and had command in his own heritage. But Upólu was one before that, from the beginning. The net of Pili was used for fishing. There was a fishing ground at the back of Asanga, and there was another fishing ground at the back of A'ana. Their names correspond with the names of the children.

Then Pili dwelt at Fasito'o with his wife until the time of her death; and then he died.

That is the end of the tale concerning Pili; from his children grew Atua and Tua-masanga and the whole of A'ana and Manono. Pili was the man that came from Manu'a and the town of Fiti-uta; Le-Fanga was the place where he grew up.

NOTES TO No. XXVI.

PAR. 1. *Pili* is a famous personage in Samoan mythology; his name means the native 'lizard,' but it would be applied also to the iguana, the crocodile, and the alligator of foreign lands.

Penga and Penga; husband and wife here have the same name; if the sense were not clear, they would be distinguished by the added epithets *tama* and *fafine*.

Three brothers; the Samoan word 'brother' is general enough in its meaning to include 'sister.'

Taken up into the heavens; the Samcans say that at first their lizards were all white, but that one of them, in some way, offended the gods and so they made this one black; and, since then, all his progeny have been black. The white ones are allowed to visit the heavens, but not the black!

Mat-flaps; see note 13 of No. XXIV.

Don't; in several of the tales, girls are represented as doing perversely that which has been expressly forbidden.

Spread a path, made a way; a mode of showing honour.

You are come; Samoan words of welcome; *there is Sina sitting there*; thus he offers her to Pili.

2. *Three birds*; here is the number three again; see note 9, No. XXX.

With luck; 'tapuaiga'; cf. the story of 'Alo-'alo.

4. *Serve*; i.e., *tua*, 'stand at the back.'

The day of the chiefs; that is a day ('aso') for consultation, when the chiefs assembled and food was provided for them by the people.

Where is the food? 'mala-mala,' a depreciatory word; 'tongs,' 'fire-rake'; they want to annoy him by these questions.

5. *Distribution*; this is equivalent to a will among us; cf. Jacob's death-bed allotment of blessings to his sons, in Genesis xlix.

Look and observe. The position of the little island of Manono gives it the function and importance of a watch-tower.

With his wife; *lit*, 'with his double.'

XXVII.—'O LE SOLO IA PILI (1)—A 'Solo.'

1. Penga and Penga are her parents.
2. The family of Penga covered up and hid the well of water;
3. Let times of distress come and we will go there—
4. To the water of Muli-papanga in Fiti-uta—
5. The spring that bursts forth; Pili is there.
6. Black was he that climbed up there,
7. Because he had been disrespectful to the gods.

8. O Sina, Sina went down
9. To draw water, but she was taken by surprise ;
10. Sina went down,
11. But the shadow of fishes was there.
12. Sina turned her back and was about to flee,
13. But he called after her, inviting her [to stay].
14. 'Sina, stand and wait ;
15. It is something that concerns your life.'
16. 'O Pule-le-'i'ite, the chief,
17. If Sina is with child, let me have the name of it, if a boy ;
18. Let something nice be brought for Pili's use ;
19. O Pule-'i'ite command
20. That native property be spread out.
21. Because Sina came, she was pregnant by me ;
22. If the child is a boy, let me have the name ;
23. But if the child is a girl,
24. I leave that to Pule-le-'i'ite.'
25. Ulu-ao and Taufai-tutu
26. Are the parents of Pili-pa'u.
27. Thy authority is over heads.

O

XXVIII.—'O LE SOLO IA PILI (2)—A 'Solo.

1. The water-Pili kept awake and listened,
2. And looked towards the doors ,
3. He searched 'mid the native mats ;
4. Her he eagerly seized ;
5. Her he caught in his grasp.
6. Sina knew, knew it well—
7. That chief had the countenance of a god ;
8. The body was that of a fish, but his side did not correspond.
9. Sina was crying convulsively
10. About that fish—whose husband he is.
11. 'Sina, stand and wait ;
12. Let us make a fresh arrangement of the lands of us two ;

13. But let Le-Folasa and Le-Fiti-uta sit still wishing success
14. To Le-Mo'e-lenga and Le-Ula,
15. To Le-Fanonga and Tu'i-Manu'a.'
16. Lua-manga-manga stood up [and said],
17. 'O Pili, turn in and let us two eat,
18. When the daily sacrifices are made for you outside ;
19. When Pili comes, we will spread out the native mats.
20. Come here into this house ;
21. That is Sina who is sitting there ;
22. It is not clear whether she will live or not ;
23. She has not reached the month of her confinement.'
24. 'O Pule-the-prophet, that is Sina who came here angry ;
25. I have counted her moons, [said Pili] ;
26. She has reached to her fourth or fifth ;
27. O chief, Pule-the-prophet,
28. Take care not to neglect her,
29. Because Sina is waiting for her confinement ;
30. She is in the house there, but she is not in her own land.
31. She will be carried off in the 'contention' before breakfast,
32. Each one with his bamboo-pillow and mat,
33. Until she bring forth ; then we shall have other tales to tell
34. About Sina ; you are to be her host and she a guest.
35. When Sina brings forth, if it is a boy,
36. Call him Fanga-api-api ;
37. He is a child of the family of Pili-mata-vave.'

O !

XXIX.—'O LE SOLO IA PILI (3)—A '*Solo*.'

1. Upólu is [a land of] heaps of tales ;
2. The pedigree of Pili is a tale in the mouth of all travellers—
3. His pedigree is a tale that travels about.
4. Pili, the chief, grew up in Manu'a.
5. Whose boy is Pili?
6. He is the son of Sina from the water.
7. If Pili comes, you two will talk together ;

8. Tell plainly whose that boy is.
9. O Pili, let your pedigree go abroad.
10. He went off in anger about a trifle.
11. The titles of Pili are [now] complete.
12. Tutuila and the village of Vatia—
13. That is your title and your [royal] seat ;
14. The Pili who dwelt there was envious
15. Of the Pili who dwelt at Oloisisina.
16. Give him the titles which he made light of in his anger.

O!

NOTES TO NOS. XXVII., XXVIII., XXIX.

XXVII.—Lines 2 - 5. *Muli-papanga*; a valuable spring which the parents wished to keep for a time of scarcity.

6. *Black*; see Note 1, No. XXVI.; *climbed up*; in the Samoan houses, lizards climb the rafters in pursuit of cockroaches and other prey.

11. *Of fishes*; that is, 'of Pili.' *Pule-le-'i'ite*; see the previous tale.

15. *Your life*; that is, 'your delivery.'

25 - 27. I do not understand what these three lines refer to. *Pili-pa'u* means the 'falling Pili'; see note to line 6. Line 27 is 'lau pule lea ua i ulu'; here *ulu* may be 'heads' or '*ulu*, 'breadfruit.'

XXVIII.—Line 1. *Water-Pili*; see Note 1, No. XXVI.

3. *Native mats*; 'tonga'; see Note 13, No. XXIV.

7. *Chief*; 'sau-ali'i,' that is, an 'aitu.'

19. *Native mats*; this is the promise of a dowry, or what we might call an 'outfit,' of household goods.

24. *Pule-the-prophet*; a translation of the name *Pule-le-'i'ite*.

31. *Contention before breakfast*; *fa'avagana*; I do not understand the bearings of this line and the next, except that the mat and bamboo pillow are used for sleeping on, and that the '*fa'avagana*' may be her kindred who come early to contend for the possession of Sina.

32. *Pili-mata-vave*; 'Pili-the-quick-eyed.'

XXIX.—Line 3. *Travels about*; that is, a tale well known in Upólu; see the prose version.

10. *A trifle*; 'mala-mala,' 'crumbs,' 'chips'; see Note 4, No. XXVI.

XXX.—THE SAMOAN STORY OF CREATION—A '*Tala*.'

[NOTE.—The title of this story in the original manuscript is '*O le tala i le tupuaga o Samoa*,' 'the Story of the growing up of Samoa,' and the date attached is 26th June, 1867.—ED.]

INTRODUCTION—1. All nations have traditions or speculations as to their own origin, and these often include a Cosmogony, by which they endeavour to account for the existence of the world, or at least of their own land, and for the creation of men to be its inhabitants. Our own Australian blacks, whom some ethnologists wrongly describe as the lowest of human beings, speak of a great Creator, known by such tribal names as Baiamai, Punjil, Nuralli, who made them and all things, and who still lives in the heavens above; in the work of creation, he carried a great knife, with which to shape the work of his hands; in this work he is assisted by a *demiourgos* whom the Kamalarai tribe call Dharamūlan, and certain birds and animals are also associated with him as agents; Punjil first made two men, each of a lump of clay, which he gradually fashioned from the feet upwards into the human form; and, as the figures grew in symmetry and beauty, he danced round them, well satisfied with his work; then he breathed very hard on them and they lived, and began to move about as full-grown men. The one had straight hair, and the other had curly hair.

2. Punjil's brother had control of all waters, great and small; and so, one day, he brought up by a hook from a muddy pool two young women, and they became the companions of the two men. Some time after, Punjil came down and visited the camp of the blacks; and, becoming very angry, he used his great knife on the men, women, and children there, and cut them into very small pieces, which still lived and wriggled about like worms; these he carried into the sky, and then dropped them wherever he pleased; the pieces became men and women, and peopled the whole land. Baiamai gave to the blacks their sacred songs and their social institutions.

There is not much of a Cosmogony in this tale, for it tells us only how men were brought into being, and how Australia came to be occupied by straight-haired and curly-haired blacks; but I have introduced it here, because it bears some relation to the Polynesian myth which I am now to make known to you.

3. The Polynesian race of the Eastern Pacific has an elaborate system of Cosmogony, which aims at explaining how the heavens were created and sustained, how gods and men came to be, how their own islands arose; but the details thereof vary much as given by the wise men in the various groups. Of these varying forms of the great Myth of Creation, the one I have here from Sāmoa seems to me to be the purest and the noblest, and to be the original from which the others have come. Any one who knows Polynesia would reasonably expect this to be so, for,

in many respects, the Sāmoans are a nobler people than most of the other islanders; they have a strong claim to be considered the parents of the race; and their highest chiefs and priests were the depositaries of the old traditions and beliefs. The present myth was communicated by one of these old chiefs, Tāua-nu'u of Manu'a, and, as Mr. Powell who got it had his full confidence, I have no doubt that this is a genuine and uncorrupted record. In estimating its value, we must always bear in mind that natives consider their traditional records as property which ought not to be shared with strangers; if circumstances compel them to open their stores against their will to foreigners, they so abridge or mutilate the narrative that it is then of little value, and, only when there is mutual confidence and trust as between friends, will they consent to tell the tale in its fulness and purity. Now, it is evident that this condition of friendship existed between Tāua-nu'u and Mr. Powell. Hence my belief in the genuineness of this record.

4. There is much simple dignity in the opening sentence of the myth—"The god Tangaloa dwelt in the Expanse" as the sole intelligence there. He was soon to be the creator of all things, but as yet there was no sky, no sea, no land. He moved to and fro in the Expanse.

It is noticeable that this opening sentence of the myth assumes the prior existence of three things before the work of creation began—(1) an Expanse or Firmament, (2) an intelligent and self-existing creative principle, 'le atua Tagaloa, the god Tangaloa, and (3) the material wherewith to form the earth. There is here no notion that the earth was formed out of nothing. There is, however, an implied belief in the eternity of matter,—the matter, at least, which became the primitive *papa*, 'rock.' And also there was an Expanse, a sort of illimitable space—and that is a necessary belief in every creation-myth,—but there was no sky, that is, no cloud-land or rain-land such as is now over the earth, and there was Tangaloa, moving to and fro at will in the Expanse. I therefore take Tangaloa to be the Aether of other cosmogonies,—the bright and pure principle of light and heat which existed before the sun, and which spread everywhere in that earliest state of things which we call Chaos. And, as this myth goes on, we shall find that, according to Polynesian belief, after the heavens and the earth had been made, this same Tangaloa places himself in the highest heavens, the Ninth, the clearest empyrean—where no cloud ever comes,—and there he dwells, calm and undisturbed, in his fale'ula, his 'palace of brightness.' So I see nothing sordid in these three Polynesian ideas; the whole presents itself to me as a very chaste opening to a Creation-myth.

In this same sense, Charles Kingsley eloquently says:—"Those simple-hearted forefathers of ours said within themselves 'Where is the All-father'? Then they lifted up their eyes to the clear, blue sky, the boundless firmament of heaven. That never changed; that was always the same. The clouds and storms rolled far below it, and all the bustle of this noisy world; but there the sky was still, as bright and calm as ever. The All-Father must be there, unchangeable in the unchanging heaven; bright, and pure, and boundless, like the heaven; and like the heavens too, silent and far off. So they named him after the heaven, Tuisco—the God who lives in the clear heaven, the heavenly father. He was the Father of Gods and men; and man was the son of Tuisco and Hertha—heaven and earth."

Now as to the meaning and derivation of the name Tangaloa, I may call to your remembrance the fact that the Anglo-Saxon god-name, Tuisco, is of the same origin as the *Eng.* word *day* and *Lat.* *dies*; the old Aryan root is *dyu* or *div*, 'to shine,' which gives other god-names, the *Sans.* *Dyaus* and *deva*, the *Gr.* *Zeus* and *Zēn*, and the *Lat.* *Jupiter*, *Jovis*, as well as the common noun *divus*. The idea common to them all is that of 'bright, lustrous, beaming,' and this fits in with the fact that Tangaloa dwells in the empyréan above. But, in seeking for a derivation of the name Tangaloa, I call to mind the Polynesian tradition that originally the sky lay flat on the lower world, *la lo-langi*, as they call it, the 'under-the-sky,' and that the nine heavens, being now propped up, surround the earth and envelope it on all sides. Therefore I divide the name Tangaloa into two parts *tanga* and *loa*; in Samoan the verb *ta'ai*, that is, *takai* (= *tangai*) means, to 'wind round' like an ulcer encircling a limb, and *ta'aiga* is a 'roll,' of mats or tobacco or the like. In the Maori dialect, *tangai* is the 'bark' or 'rind,' that which 'envelopes,' and *takai* is a 'wrapper'; in Samoan *tanga* is a 'bag,' that which 'envelopes' or 'encloses.' I would therefore say that the name was at first *Tanga-la*, then lengthened into *Tanga-loa*,—'the god that encompasses all things,' 'the encircling Aether'; but, as *-la* is not a common formative in Polynesian dialects, at least so far as I know, it is quite possible that *-loa* is a separate word, and may be the Samoan *loa*, 'long,' 'far off.'

5. The myth next goes on to say that, in his wandering to and fro in the Expanse, Tangaloa one day stood still, and then there grew up *pāpā*, 'a rock,' for him to rest on. In another Samoan myth, '*le Solo o le Va*,' Tangaloa is, at another time, weary of flying over the waste of waters, and no sooner does he express a wish for a resting place, than an island

rises up from the deep for him. In both cases, there is no laborious work of creation ascribed to him, but his wish or his need at once produces the result desired. There is certainly some dignity in this.

The word *pāpā*, in Samoan, means 'rock,' but in other dialects it also means 'foundation,' 'anything level or flat,' and *pala*, means 'mud.' Now I take the myth here to indicate that, by the exercise of his will alone, Tangaloa caused to spring up, out of chaos, first the solid foundation-material out of which the Earth, the Sea, the Sky, were afterwards evolved by separate flats or acts of creation; for the myth then declares that he spake to the Rock, saying 'Be thou split open,' and there came forth, as if by successive efforts of parturition, various kinds of foundation-stuff, then the Earth, then the Sea, and Fresh-water, and the Sky, and 'Prince-Prop-up-sky,' and Immensity, and Space, and Height, and, last of all, Man, as a physical being, but not yet endowed with intelligence. Unlike the original *papa*, all of these come into existence, not at his will, but by the power of a separate command of evolution for each.

I am not much concerned to explain how, on natural principles, the Sea, and the Sky, and Man himself, can have been produced by this *papa*, but the succession of ideas in this Samoan myth is consistent; for first comes the Rock or Foundation—the physical origin of all things—then the varieties of rock, which are soon united to form the Earth; then the Sea, '*le tai*,' is made to surround the Earth and lave its shores; then its counterpart, '*le vai*,' Fresh-water, appears on the Earth; hitherto Earth and Sky had been as one, but now the Sky is lifted up above the earth and secured in its place by props; then the dimensions Length, Breadth and Height appeared; and then, all things being ready for him, Man came upon the scene.

6. But Man was yet a dull, inert mass of matter; so Tangaloa created Spirit, and Heart, and Will, and Thought, and put them within him, and thus Man became a living soul. Here the myth duly recognises the composite nature of man, and that too with a precision scarcely to be expected from Polynesians.

7. The Kosmos had been, to some extent, arranged already as Land, Sea, and Sky, but now that Man is to dwell on earth, Tangaloa proceeds to make him comfortable; and so he sends Immensity and Space, as a wedded pair, to dwell in the sky above; he bids another pair, 'Two-clouds' and 'Two-fresh-water-bottles,' attend to the supply of water from the clouds, and another pair to people the Sea. Meanwhile the man and his wife are to people the earth on its southern side. But now a catastrophe seems to have happened, for *Tui-te'e-langi*, the Polynesian Atlas, found

himself unable any longer to support the weight of the sky, and so it fell down on earth once more. Then Tui bethought him of two native plants that grow, spread out a-top like an umbrella; with these he propped up the sky, and it has never fallen since! In this connection, it is curious to note that our Australian Aborigines believe similarly that the sky is held up by props, and they have a tradition that the props once broke, and then the wizards had great work to do in getting the sky propped up again.

8. The wedded pair, Immensity and Space, that had a little before been removed from the earth to the sky, now brought forth children—Night and Day, and these two, by their united action, produced the Sun and the Stars; these two dwell in the First Heavens, the region of alternate darkness and brightness. Immensity and Space next gave birth to Le-Langi, 'the clear, blue sky'; that is the Second Heavens. Langi then produces all the other heavens up to the Ninth, and each of these is peopled by Immensity and Space. All this means that, above the cloud land of the First Heavens, everything is serene, calm, and clear, and everywhere there is illimitable extension of space. So it must have appeared, at all events, to the earliest myth-makers, when they turned their thoughts from earth to heaven.

9. Our myth now turns to the creation of the other gods; every one of these, however, is a Tangaloa, and is therefore not a separate and independent being, but only a phase, as it were, of the supreme Tangaloa—a distinct manifestation of himself in some one or other of his functions. These he created, but the word used here, *fa'a-tupu*, only implies that he 'caused them to grow up' or to be. Of all these facets of himself, he makes Tangaloa-le-fuli, 'the immoveable,' to be the chief, for up there, in his domain, the Ninth Heavens, the clouds 'never roll along' (*le fuli*), the storms below never come nigh, and all is tranquillity and peace.

10. The myth next shows the Sāmoan pride of race, for it makes Sāmoa and Manu'a to be brothers of the Sun and the Moon. And yet we cannot believe that the Polynesians are akin to the rulers of the Celestial Empire. After these, the other islands of the Pacific, as known to Sāmoans, —Tonga and Fiji and the Eastern groups—are made to spring up at the will of 'Tangaloa-the-creator-of-lands.' This is a much more dignified account of things than that which is given in some other Polynesian legends, which say that, while one of the gods was engaged fishing in the sea, he pulled up with his line an island here and there; and that had not the line at last broken with the pull, some of these islands might have been continents.

11. But the newly-created islands are, as yet, rough and rugged and unfit for the occupation of man; and so 'Tangaloa-the-creator' comes down and treads upon them, and prepares them for people to dwell in. And he looked on all his work, and said, 'It is good.' To people these lands, he causes Tangaloa-sāvāli to take a native climbing-plant, a Fue, and lay it outside in the sun. Under the Sun's heat, its juice brought forth a great multitude of worms; these Tangaloa fashioned into men and women, and gave them intelligence, and thus he peopled the lands. This Fue must represent some echo of the original creation of mankind by God, for our myth says, at its close, that Fue was the son of Tangaloa, and there is still in Sāmoa a variety of this vine, which is called Fue-sā, the 'sacred vine.' And, to Sāmoans, such origination of life is intelligible; for they have experience of animal life as a product of the sun's heat; to procure oil, they slice their cocoa-nuts into lumps, and, leaving a heap of this 'copra' exposed in a canoe, they find that it soon produces oil and worms.

12. As a parallel to this account of the origin of man, I now refer to the Australian tradition with which I began this introduction. There, the creation-god is Baiamai, that is, Bai-bai, an intensive and therefore honorific name, formed from the Australian root-word ba, 'to cause to be,' 'to make'; similarly, the verb punjilko, that is, punjil with the infinitive suffix -ko added, means 'to cut out,' 'to shape,' 'to make'; hence Baiamai and Punjil simply mean 'the creator.' In his creative work, Punjil uses a knife wherewith to shape all things; similarly Tangaloa cuts and shapes the vine-worms 'into member'd forms.' Punjil too, when he wishes the land to be occupied, cuts the people into small worm-like pieces and scatters them about. Tangaloa declares himself well pleased with his handiwork; Punjil, in delight, dances around the clay image of the man which he was making. Tangaloa gives spirit and heart to animate man; Punjil breathes hard on his image, and the man lives. Tangaloa, in one of his aspect, is the lord of the sea; Punjil's brother is the lord of all waters. Baiamai gave to the Australians all their social regulations; so also, among the Polynesians, all authority comes from Tangaloa; he gave them kingly rule, and the right of holding councils, and enjoined them to live in peace.

And thus, in folk-lore and in tradition-myths, parallel stories may be found in the most unlikely quarters, all the world over, and these parallels can scarcely have proceeded from merely a similar power of invention in so many diverse nations; they seem to indicate a common origin.

The 'Tala.'

13. The god Tangaloa dwelt in the Expanse; he made all things; he alone was [there]; not any sky, not any country; he only went to and fro in the Expanse; there was also no sea, and no earth; but, at the place where he stood, there grew up a rock. Tangaloa-fa'a-tutupu-nu'u was his name; all things were about to be made by him, for all things were not yet made; the sky was not made, nor any thing else; but there grew up a Rock on which he stood.

14. Then Tangaloa said to the Rock, 'Be thou split up.' Then was brought forth Papa-taoto; after that, Papa-sosolo; then Papa-lau-a'au; then Papa-'ano-'ano; then Papa-'ele; then Papa-tu; then Papa-'amu-'amu and his children.

15. But Tangaloa stood facing the west, and spoke to the Rock. Then Tangaloa struck the Rock with his right hand, and it split open towards the right side. Then the Earth was brought forth (that is the parent of all the people in the world), and the Sea was brought forth. Then the Sea covered the Papa-sosolo; and Papa-nofo [that is, Papa-taoto] said to Papa-sosolo, 'Blessed are you in [the possession of] your sea.' Then said Papa-sosolo 'Don't bless me; the sea will soon reach you too.' All the rocks in like manner called him blessed.

16. Then Tangaloa turned to the right side, and the Fresh-water sprang up. Then Tangaloa spake again to the Rock, and the Sky was produced. He spake again to the Rock and Tui-te'elangi was brought forth; then came forth Ilu, 'Immensity,' and Mamao, 'Space,' came (that was a woman); then came Niua.

17. Tangaloa spake again to the Rock; then Lua-'o, a boy, came forth. Tangaloa spake again to the Rock, and Lua-vai, a girl, came forth. Tangaloa appointed these two to the Sā-tua-langi.

18. Then Tangaloa spoke again and Aoa-lālā, a boy, was born, and [next] Ngao-ngao-le-tai, a girl; then came Man; then came the Spirit; then the Heart; then the Will; then Thought.

19. That is the end of Tangaloa's creations which were produced from the Rock; they were only floating about on the sea; there was no fixedness there.

20. Then Tangaloa made an ordinance to the Rock and said:—

(1) Let the Spirit and the Heart and Will and Thought go on and join together inside the Man ; and they joined together there and man became intelligent. And this was joined to the earth ('ele-ele'), and it was called Fatu-ma-le-'Ele-'ele, as a couple,* Fatu the man, and 'Ele-'ele, the woman.

(2) Then he said to Immensity and Space, 'Come now ; you two be united up above in the sky with your boy Niuao, then they went up ; there was only a void, nothing for the sight to rest upon.

(3) Then he said to Lua-'o and Lua-vai, 'Come now, you two, that the region of fresh-water may be peopled.'

(4) But he ordains Aoa-lālā and Ngao-ngao-le-tai to the sea, that they two may people the sea.

(5) And he ordains Le-Fatu and Le-'Ele-'ele, that they people this side ; he points them to the left-hand side, opposite to Tualangi.

(6) Then Tangaloa said to Tui-te'e-langi, 'Come here now ; that you may prop up the sky.' Then it was propped up ; it reached up on high. But it fell down because he was not able for it. Then Tui-te'e-langi went to Masoa and Teve ; he brought them and used them as props ; then he was able. (The *masoa* and the *teve* were the first plants that grew, and other plants came afterwards). Then the sky remained up above, but there was nothing for the sight to rest upon. There was only the far-receding sky, reaching to Immensity and Space.

* NOTE.—Mr. Powell's manuscript, under date March 21, 1871, has this note :—"To-day Taua-nu'u has explained to me the reason of his reluctance to disclose his traditions ; he is afraid lest contention arise, when it is found that they place Savai'i and Upōlu in a position inferior to his own islands of Manu'a. When I promised due care, he opened his treasures more fully. He states that (1) 'Ele-'ele is distinct from Fatu-ma-le-'Ele-'ele ; that was the name given to the first man, who was only at first floating about on the waters with 'Ele-'ele. Fatu-ma-le-'Ele-'ele was formed by the union of Spirit, Heart, Will, and Thought, and was appointed to people the lands in conjunction with 'Ele-'ele 'Earth,' but Le-'Ele-'ele was different, and Fatu was different from 'Ele-'ele.

The Production of the Nine Heavens.

21. Then Immensity and Space brought forth offspring ; they brought forth Po and Ao, 'Night and Day', and this couple was ordained by Tangaloa to produce the 'Eye-of-Sky,' [the Sun]. Again Immensity and Space brought forth Le-Langi; that is the Second Heavens ; for Tui-te'e-langi went forth to prop it up and the sky became double ; and Immensity and Space remained there, and they peopled the sky. Then again Langi brought forth, and Tui-te'e-langi went forth and propped it up ; that was the Third Heavens ; that was peopled by Immensity and Space. Then Langi bore again ; that was the Fourth Heavens. Tui-te'e-langi went forth to prop it up ; that heaven also was peopled by Ilu and Mamao. Then Langi bore again ; that was the Fifth Heavens. Then went forth Tui-te'e-langi to prop it up ; that heaven also was peopled by Ilu and Mamao. Langi brought forth again ; that was the Sixth Heavens. And Tui-te'e-langi went and propped it up ; that heaven was peopled by Ilu and Mamao. Then Langi bore again ; that was the Seventh Heavens. And Tui-te'e-langi went forth and propped it up ; that heaven was peopled by Ilu and Mamao. Then Langi again brought forth ; that was called the Eighth Heavens. Tui-te'e-langi went to prop up that heaven ; and that heaven was peopled by Ilu and Mamao. Then again Langi brought forth ; that was the Ninth Heavens ; and it was propped up by Tui-te'e-langi ; and that heaven was peopled by Ilu and Mamao. Then ended the productiveness of Ilu and Mamao ; it reached to the Ninth Heavens.

The Production of other Gods.

22. Then Tangaloa sat [still] ; he is well-known as Tangaloa-fa'a-tutupu-nu'u ; then he created Tangaloa-lē-fuli and Tangaloa-asiasi-nu'u and Tangaloa-tolo-nu'u and Tangaloa-sāváli ; and Tuli also and Longonoa.

23. Then said Tangaloa, the creator, to Tangaloa-lē-fuli, 'Come here ; be thou chief in the heavens.' Then Tangaloa, 'the immoveable,' was chief in the heavens.

24. Then Tangaloa, the creator, said to Tangaloa-sāváli, 'the messenger,' 'Come here; be thou ambassador in all the heavens, beginning from the Eighth Heavens down to the First Heavens, to tell them all to gather together in the Ninth Heavens, where Tangaloa, the immoveable, is chief. Then proclamation was made that they should go up to the Ninth Heavens, and then visit below the children of Night and Day in the First Heavens.

25. Then Tangaloa, the messenger, went down to Night and Day in the First Heavens, and asked them thus:—'Have you two any children appointed to you?' And they answered, 'Come here; these two are our children, appointed to us, Langi-uli and Langi-mā.

26. All the stars also were their offspring, but we do not have the names of all the stars (the stars had each its own name), for they are forgotten now, because they dropped out of use. And surely the last injunction of Tangaloa, the creator, to Night and Day was that they should produce the Eye-of-the-Sky. That was the reason Tangaloa, the messenger, went down to ask Night and Day in the First Heavens [if they had any children].

27. Then answered Night and Day, 'Come now; there remain four boys that are not yet appointed,—Manu'a, Sāmoa, the Sun, and the Moon.'

28. These are the boys that originated the names of Sāmoa and Manu'a; these two were the children of Night and Day. The name of the one is Sā-tia-i-le-moa, 'obstructed by the chest'; the meaning of which is this:—the boy seemed as if he would not be born, because he was caught by the chest; therefore it was he was called Sā-tia-i-le-moa, that is, Sāmoa; the other was born with one side abraded ('manu'a'); then said Day to Night 'Why is this child so greatly wounded?' therefore the child was called 'Manu'a-tele.'

29. Then said Tangaloa, the messenger, 'It is good; come now; go up into the Ninth Heavens, you four; all are about to gather together there to form a Council; go up you two also.' Then they

all gathered together in the Ninth Heavens,—the place where dwelt Tangaloa, the creator, and Tangaloa, the immovable ; the Council was held in the Ninth Heavens ; the ground where they held the Council was Malaē-a-Toto'a, 'the council ground of Tranquillity.'

30. Then various decrees were made in the Ninth Heavens ; the children of Ilu and Mamao were appointed all of them to be builders, and to come down from the Eighth Heavens to this [earth] below ; perhaps they were ten thousand in all that were appointed to be builders ; they had one name all were [called] Tangaloa. Then they built houses for the Tangaloa ; but the builders did not reach to the Ninth Heavens—the home of Tangaloa-lē-fuli—which was called the 'Bright House' [fale-'ula].

31. Then said Tangaloa, the creator, to Night and Day :—'Let those two boys go down below to be chiefs over the offspring of Fatu and 'Ele-'ele.' But to the end of the names of the two boys was attached the name of Tangaloa-lē-fuli who is king ('tupu') of the Ninth Heavens ; hence the [Samoan] kings ('tupu') were named 'Tui o Manu'a-tele ma Samoa atoa.'

32. Then Tangaloa, the creator, said to Night and Day :—'Let those two boys, the Sun and the Moon, go and follow you two ; when Day comes, let the Sun follow ; also when Night comes, the Moon too comes on.' These two are the shades of Tangaloa ; they are well-known in all the world ; the Moon is the shade of Tangaloa ; but thus runs the decree of Tangaloa, the creator,—'Let there be one portion of the heavens, in which they pass along ; in like manner also shall the Stars pass along.'

33. Then Tangaloa, the messenger, went to and fro to visit the land ; his visit began in the place where are (now) the Eastern groups ; these groups were made to spring up ; then he went off to cause the group of Fiji to grow up ; but the space between seemed so far off that he could not walk it ; then he stood there and turned his face to the Sky, [praying] to Tangaloa, the creator, and Tangaloa, the immovable ; Tangaloa looked down to Tang-

aloa, the messenger ; and he made the Tongan group spring up ; then that land sprang up.

34. Then he turns his face to this Manu'a ; and looks up to the heavens, for he is unable to move about ; then Tangaloa, the creator, and Tangaloa, the immoveable, looked down and caused Savai'i to spring up ; then that land grew up.

35. Then Tangaloa, the messenger, went back to the heavens, and said—' We have (now) got countries, the Eastern group and the Fiji group, and the Tongan group, and Savai'i.' Then, as all these lands were grown up, Tangaloa, the creator, went down in a black cloud to look at the countries, and he delighted in them ; and he said, 'It is good' ; then he stood on the top of the mountains to tread them down, that the land might be prepared for people to dwell in. Then he returned [on high]. And Tangaloa, the creator, said [to Tangaloa, the messenger],—' Come now ; go back by the road you came ; take people to possess the Eastern groups ; take Atu and Sasa'e ; that is a pair ; they were called conjointly Atu-Sasae ; these two people came from the heavens from among the children of Tangaloa.

36. Then Tangaloa, the messenger, went again to the Fiji group ; he also again took two persons, a pair ; their names were Atu and Fiji from among all the children of Tangaloa ; so that group of islands was called Atu-Fiji.

37. Then he turned his face towards Tonga ; he took [with him] a couple ; their names were Atu and Tonga ; these two peopled that group of islands ; their names were the Atu-Tonga ; these two were the people of Tangaloa.

38. Then Tangaloa, the messenger, came back to this Manu'a, to Le-Fatu and Le-'Ele-'ele and their children ; because the command of Tangaloa, the creator, [had gone forth] from the heavens, that Le-Fatu and Le-'Ele-'ele should go there to people this side of the world. Then went out Valu'a and Ti'āpā to people Savai'i ; these two are the children of Le-Fatu and Le-'Ele-'ele ; these two people are from this Manu'a ; Savai'i and this Manu'a are one ;

these two were the parents of I'i and Sava ; I'i was the girl and Sava was the boy ; that island was peopled by them and was named Savai'i.

39. And Tangaloa, the messenger, went again to this Manu'a ; then he stood and faced the sky, as if he were making a prayer ; then Tangaloa, the creator, looked down, and the land of Upólu sprang up. Then Tangaloa, the messenger, stood and again faced the heavens towards Tangaloa, the creator ; and Tangaloa, the creator, looked down from the heavens, and the land of Tutuila sprang up.

40. Then Tangaloa, the messenger, turned to the heavens and said, 'Two lands are now gotten for me to rest in.' And Tangaloa, the creator, said,—'Come now ; go you with the Peopling-vine ; take it and place it outside in the sun ; leave it there to bring forth ; when you see it has brought forth, tell me.' Then he took it and placed it in Salēa-au-mua, a council-ground, which is now called the Malae-of-the-sun. Then Tangaloa, the messenger, was walking to and fro ; and he visited the place where the Fue was ; he went there and it had brought forth. Then he went back again to tell Tangaloa, the creator, that the Fue had brought forth. Then Tangaloa, the creator, first went down ; he went to it ; he looked and it had brought forth something like worms ; wonderful was the multitude of worms ; then Tangaloa, the creator, shred them into strips, and fashioned them into members, so that the head and the face and the hands and the legs were distinguishable ; the body was now complete, like a man's body ; he gave them heart and spirit ; four persons grew up ; so this land was peopled ; there grew up Tele and Upólu which are the children of the Fue ; Tutu and Ila, that is a pair ; these are the children of the Fue ; four persons, Tele and Upólu, Tutu and Ila. Tele and Upólu were placed to people the land of Upolu-tele ; but Tutu and Ila, they two were to people the land now called Tutuila.

41. Fue, the son of Tangaloa, that came down from heaven, had two names, Fue-tangata and Fue-sā ; he peopled the two flat lands.

42. Then Tangaloa gave his parting command thus :—‘Always show respect to Manu‘a ; if any one do not, he will be overtaken by calamity ; but let each one do as he likes with his own lands.’

43. [Here] the story of the creation of Sāmoa finishes with this parting command, which was given at Malae-Lā.

NOTES TO THE STORY OF CREATION.

PAR. 1. *Punjil*; for an account of Punjil and his works, see R. Brough Smyth’s “Aborigines of Victoria,” Vol. I., and for Baiamai, see Ridley’s “Kamilaroi.”

Baiamai; in the text I have given this form of the name, for it is the common one ; but I think that it ought to be written Ba-ye-mai; for *ba* is the root ‘to make,’ *ba-yé* means ‘one who makes,’ and *mai* is a formative termination.

Kamalarai; this name for a native language and tribe in New South Wales has always been written Kamilaroi; but the composition of the word requires the spelling Kāmālarai, for it is made up of *ka* (dialect *kya*) ‘not,’ *-mal* and *-arai*, which are common formative suffixes.

Dhara-mulan; a demiurge figures in many of the ancient cosmogonies. The Egyptian demiurge Thoth created light for the world, while as yet there was no sun, and in the Orphic hymns, light exists before the sun; cf. note 4, s. v. *Aether*. In the Kamalarai legends, Dhara-mulan seems to have a two-fold aspect, and hence the *-mulan* in his name may be the word *bula*, ‘two.’

Breathed very hard; cf. “He breathed into his nostrils the breath of life.” The Polynesian here and in other respects agrees with the Egyptian and the Hebrew Cosmogonies, which commence with chaos, regard light as anterior to the sun, postulate the moulding hand of a deity in creation and a divine breath as the source of life. The Polynesian cosmogony has also, the idea of the unity of God; for the gods are all Tangaloa. It agrees with the Avesta in tracing creation to the will of a deity and in ascribing perfection—“it is good”—to the thing created; Ahuramazda is the sole creator who made heaven and earth and men. In India also, the Self-existing One *by a thought* made the waters. The Babylonian Cosmogony considers water as the primal element from which life came; the Polynesian does not.

2. *Punjil’s brother*; cf. the relation of Zeus to Poseidon.

Cut into pieces; cf. the Hebrew verb *bārā*, ‘to create,’ which properly means ‘to fashion,’ ‘to shape.’

Worms; cf. a subsequent note on *Fue-tagata*.

3. *The details thereof*; for these, see Rev. Dr. Gill’s “Myths and Songs” and Sir George Grey’s “Polynesian Mythology.”

4. *Le atua Tagaloa*; this expression shows that this myth is not modern; for the word *atua*, 'god,' was almost obsolete when the first missionaries went to Samoa.

Aether; some commentators on Gen. I., 1-2 assert that the ancient Jews believed the sky to be a solid vault, but that in its original state (verse 1) it was a liquid expanse; the 'separation' of the material of heaven and earth took place on the second day of creation (verses 6-8).

Envelopes; the Polynesian conception of the Heavens does not seem to include a belief that they encompass the world *all round* like a circle—not spheres, but crescent-shaped vaults. This also is the Hebrew notion; cf. "He that sitteth upon the circle of the earth; that stretcheth out the heavens as a curtain, and spreadeth them out as a tent to dwell in" (Is. xl., 22). "He walketh in the circuit of heaven" (Job. xxii., 14).

Fale-ula; cf. the 'Solo o le Va.'

5. *Papa*; not a 'rock' in our sense of the word, but merely 'something flat and solid'; cf. Gen. I., 6-8. In the sense of 'foundation,' *papa* has numerous correspondences in the Hebrew Scriptures; cf. Isaiah xxxi., 17, "the earth's foundation quake"—the foundations which support the visible frame of the earth.

Separate flats; this cosmogony is thus theistical, not pantheistical.

Prince-Prop-up-sky; Tui-te'e-langi; his place here, among the physical creations of Tangaloa, shows that he is not a god—not a Tangaloa,—but a sort of physical Atlas.

The sky is lifted up; cf. the English word 'heaven' and the Scotch, 'lift.'

6. *Dull, inert mass*; it had the worm-life from the Fue-sā, but that was all.

7. *Southern side*; the limited knowledge which the ancients had of geography led them to regard the north as hyperborean; and thus the south was to them the habitable part of the globe.

8. *Sun and stars*; so also in Genesis I., the sun does not appear till the fourth day. In our myth, there is no mention of the moon till further on.

9. *Ninth Heavens*; 'three times three'; cf. the notes on this point in the 'Solo o le Va.' In the "Records of the Past," we read of the 'nine gods, the masters of things,' and of a 'holy nine.' As the basis of their numeration, the Polynesians have—one, two, three; they have no knowledge of seven as a perfect number.

Tranquillity and peace; cf. the notes on this point in the 'Solo o le Va.'

For the occupation of man; it seems to me that whatever is essential to the Polynesian idea of creation is contained in this verse—"He that created (*bārā*) the heavens" &c. (Is. xlii., 5) see below, note 13.

11. *Outside in the sun*; cf. the reverence given to the *scarabæus*, as a product of the Nile mud under the heat of the sun.

Fashioned into men; cf. Heb. *bār ā*, as above.

12. *Into member'd forms*; see the 'Solo o le Va.'

13. *The god Tangaloa.* He is the great god of the Polynesians; cf. the notes on 'le Solo o le Va.'

The Expanse; 'va-nimo-nimo' is the word used here. *Va* means space between any two things; it may be as small a space as that between two laths on a partition wall or the planking on a ship's deck; but it may include as much as the east is distant from the west; *nimo-nimo* means 'far, far distant.' I therefore take *va-nimo-nimo* to mean 'vastly extended space'—so vast that the mind cannot compass it. In Samoan, *nimo-nimo* is said of any thing that has quite passed from the memory; and a lark soaring aloft and thus going out of sight would be said to *nimo-nimo*. The word *mamao*, which occurs further on, also means 'space,' but it seems to differ from *va-nimo-nimo* in that it is used of a measurable distance between objects; it may be translated 'extension.' The difference may thus be that *va-nimo-nimo* is 'unlimited extension,' whereas *mamao* is 'limited extension.' In Genesis I., 6, the 'firmament' is the Hebrew *rakîā*, that which is 'spread out,' and seems to correspond with the 'expanse' here. In Gen. I., 2, "the Spirit of God moved ('brooded') on the face of the waters"; here it is said that Tangaloa *fe-alu-alu-mai*, 'goes backwards and forwards'; *alu* means to 'go'; the prefix *fe* has a reciprocal force; *alu-alu* is a reduplication of intensity; the *-mai* is a formative termination. In the 'Solo o le Va,' Tuli, which is the *ata* or spirit-emblem of Tangaloa-savali, is tired of moving to and fro, and desires a place to rest on; forthwith upsprang Manua's Rock. So also in this myth; where Tangaloa halted from his wandering to and fro, on that spot a Rock sprang up. In line 32 of that same Solo, the footstool of Tangaloa is called *taa-tuga*, 'that on which he stands'; with this compare "Heaven is my throne, earth is my footstool; . . . what is the place of my rest." Here comes in the ancient idea that the heavens were a solid vault; cf. *Gr.* 'stereoun,' 'stereoma'; *Lat.* 'firmamentum.'

He made all things; 'na faia mea uma'; with this compare, "And without him was not anything made that was made."

No earth; the word here is *lau-'ele'ele* which means 'land spread out'; '*ele'ele* elsewhere is merely 'earth, soil, dirt'; the *lau* here prefixed denotes 'breadth'; cf. the 'broad-bosomed' earth of Hesiod. With the meaning of *lau-'ele'ele* compare Isaiah xlii., 5, "Thus saith God the Lord, he that created (cf. *Heb.* bârâ) the heavens and stretched them out (cf. Samoan *va-nimo-nimo* and *Heb.* rakîa); he that spread forth the earth (cf. *lau-'ele'ele*) and that which cometh out of it; he that giveth breath unto the people upon it (cf. 'Solo o le Va,'), and spirit (cf. *anga-anga*) to them that walk therein." The Hebrew verb there, '*rākâ*,' properly signifies to spread out by 'trampling' on with the feet or 'beating' into thin plates. In Samoan, *lau* has a similar reference; for, of its compounds, *lau-lelei* means 'even, level,' *lau-papa* is a 'board, a plank,' *lau-tele* is 'wide,' and *lāu* itself, as a prefix to verbs, denotes 'uniformity' and 'universality,' as if 'spread out.'

T.-fa'a-tutupu-nu'u; here *fa'a* (dialects, *ba-ka*, *fa-ka*, *wha-ka*) is a causative prefix to verbs, very abundantly used in Polynesian; *tupu*, as a verb, means 'to grow,' 'to spring up'; *tutupu* is its plural form; *nu'u* means 'a country,' 'a district.' The whole name thus means 'Tangaloa, the creator of lands.'

A rock grew up; 'tupu ai le papa.'

14. *Be thou split open*; 'māvae ia,' said of parturition; *māvae*, 'to open as a crack'; hence *māvava*, 'to yawn.'

Brought forth; the word is *fanau*, which is also applied to the extrusion of gum from trees. The next acts of creation are in the text expressed in each case, by *toe fanau*, 'again it brought forth,' but, for brevity, our translation says only 'after that'; 'then.' With *fanau* compare:—"Before the mountains were brought forth" (*Heb. yullād*)—Psalm xc., 2.

Papa, 'rock'; it also means 'plain, level, flat,' and that meaning is in harmony with the 'spread out' of the note above. To the Polynesian myth-makers, their mountains, being mostly volcanic, do not belong to the earliest stages of creation. The various kinds of 'papa' are indicated by the epithets attached, viz., *ta'oto*, 'to lie down'; *sosolo*, 'to run,' 'to spread like creeping plants'; *lau-a'au*, 'resembling a flat reef' (*a'au* is a 'reef,' and to 'swim'; *lau* denotes uniformity); *ano-ano* is 'honey-comb'; *ele* is a sort of volcanic mud or shale, so soft that it can be cut with an axe; *tu* means 'to stand' (its derivative, *tugā*, means 'standing in the way,' as a rock in the middle of the road); *amu-amu* is a kind of 'branching coral,' branching like fingers.

Children; the word here is *pau*, not *fanau*, 'offspring.'

15. *Facing the west*; in the ancient auguries and other ceremonials, the position of the celebrant was important.

Towards the right. Mr. Powell says here—"in the direction of *tualagi*, 'the back of the sky' the north," cf. Ovid *Meta.* I. 2, 45. 'Right' and 'left' are equivalent to 'north' and 'south', cf. Ps. lxxxix., 12; Is. liv., 3. To the Kelts of Scotland and Ireland, the 'right' hand is still the 'south' hand (de as for *deaks*, 'right'; cf. *Gr.* dex-ios, *Lat.* dex-ter, 'right'); because, when the face is turned towards the east, the south is on the right. An old custom among them—said to have come down from the Druids—is called *deas-i-ùil*, 'a turn to the right'; because, in all their solemn processions, the company, in order to secure a blessing, turns to the right, and, keeping the object on the right, marches round it 'three times' in the same direction as the daily course of the sun. The motion in a contrary way is *car-tual*, and is considered unlucky; in Lowland Scotch this is called a *widder-sins* motion.

World; *lalo-lagi*, 'under-the-sky.'

Earth; *'ele'ele*; this is a reduplication of *'ele*, 'red-earth,' 'rust,' 'dirt,' 'blood'; see *'ele'ele*. It is interesting to remember here that the Hebrew word *adāmāh* (cf. Adam), 'the earth,' 'the tilled ground,' comes from a

root meaning to be 'red,' and is applied also to the 'dust' which mourners use.

That is the parent, &c. With this compare, "And the Lord God formed man of the dust of the ground."

The sea; sami, 'the salt water' (Lit. *sal*), not *tai*. In Genesis i., 10, as here also, 'the seas' (Heb. *yâmim*) are gathered together when the dry land (Heb. *yâbêsh*, 'anything that is dried up or becomes dry') appears. The Samoan word *tai* means 'the sea, the tide'; the distinction between it and *sami* seems to be that *tai* is the sea where it flows upon the land, but *sami* is the big, salt ocean.

Papa-nofo probably is 'the rock (or rocks) that remained' uncovered. The idea of the myth-maker here seems to be that the *sami* at first had not depth of water enough to cover anything but the *papa-sosolo*; but that ere long the waters would rise and reach the other rocks also, and so make them happy (*amuiā*, 'blessed,' used in congratulations).

16. *Fresh-water, 'vai'*; as in the 'Solo o le Va,' so here; the *vai* comes immediately after the *tai*.

Your sea. The word here is *tai*; cf. the note on *sami*.

Brought forth; produced; come forth; in the text these are always '*fanau*.'

Sky; 'lagi'; pronounced *langi* (i=Italian i). Everywhere, the Samoan *g*=*ng*. A cognate word is the Melanesian *laga*, 'clear.'

Tui-te'e-lagi; tui, 'a high chief, a prince, a king'; *te'e*, 'to prop up'; *lagi*, 'the sky.' The Australian blacks also know that the sky is propped up; once the props broke, and the wizards (*korāji*) had the utmost difficulty in putting things right again.

Ilu, &c.; these three, *Ilu*, *Mamao*, and *Niuao* do not come into existence till after the sky is propped up; hence *mamao*, as I think, must mean 'limited extension' or 'space' from horizon to horizon, from sunrise to sunset; *niuao* is formed from *niu*, 'a cocoa-nut tree'; the Samoans say of a very tall man that he is 'a walking cocoa-nut tree'; of smoke they say *fa'a-niu tu*, 'it stands like a cocoa-nut tree'; and in the Samoan Bible the missionaries have applied the expression to the 'pillar of fire' in the wilderness; and so I think that *niuao* must mean 'height.' The Samoan word *ilu* means 'innumerable,' 100,000, or any vast number; in its place in the text, it cannot well refer to the stars in the sky; we may translate it 'immensity,' and apply it to distance from north to south. *Ilu*, *Mamao*, and *Niuao* would thus be the three dimensions formed by the bounding sky, viz., Length, Breadth, and Height, each of them, however, limited by the sky. Cf. the note on *the Expanse*.

17. *Lua'ao* and *Luavai*; *lua-vai* means 'two fresh-waters'; *lua'ao* should, I think, be *luā-o*, for *lua-ao*, 'two clouds.'

Sā-tua-lagi; the 'race' at the 'back' of the 'sky'; the north.

18. *Ngao-ngao-le-tai*, 'the desolate sea.'

'Came'; 'came forth'; the text has still the same *toe fanau*, 'again was brought forth.'

Man; 'tangata,' the human race. Last to be created was man, and the elements which are joined together to make up his composite being. These are—*anga-nga*, 'the spirit,' probably from the same root as *nga'e*, 'to breathe hard'; hence the 'breath,' the 'spirit,' in the same sense as the Heb. *ruāch*, Gr. *psuche*, Lat. *spiritus*, *animus*, Sans. *âtman*; in Samoan *anga-nga* also means 'a disembodied spirit'—*loto*, the 'heart or affections,' not the physical heart—*finagalo* 'the will,' also the 'liver'; *finagalo* is a word used only to chiefs; *finagaloa* means, 'to be angry,' 'choleric.' The next name, *masalo*, properly means 'doubt,' but this appears to be a secondary meaning, for 'doubt' arises from that power which enables the mind to cast things to and fro in reflection, and hence to deliberate; *masalo* is therefore here taken to be 'thought,' 'the power of thought.' These four Tangaloa causes to go within man's physical frame, and combine there; and thus man becomes 'intelligent, wise.' See also Ovid, *Meta. i.*, 1.

In Is. xlii., 5—the verse already quoted,—the breath and the spirit (*neshâmâh* and *ruāch*) are distinguished; the one is the animal spirit or life; the other is the spirit which gives consciousness. Similarly, the Melanesians and Polynesians believe that man has *two* spirits—the one may leave him for a time when he is dreaming or in a faint; the other finally leaves his body at death.

19. *No fixture*; *ua lei se mea a mau ai*, 'there was nothing to be fast to'; *ope-opea*, 'they floated about.' Cf. "The earth was without form and void"; cf. also Ovid, *Meta. i.*, 1.

An ordinance; 'tofiga.' This word comes from the verb *tofi*, 'to divide an inheritance,' 'to apportion a father's property among children.' Tangaloa's *tofiga* is thus the exercise of his sovereign pleasure in allotting to his children their several stations and spheres of action, as indicated in the five paragraphs which follow.

Intelligent, 'atamai.' As a verb this word means 'to understand'; as an adjective, 'clever, intelligent, sensible'; as a noun, 'the mind.' The Samoan *ata* denotes the incorporeal shadow or spirit, as opposed to the substance of a thing; and *atamai* may be a derivative from it; so also the French *esprit* and *spirituel* are related. The Sanskrit *âtman* also means 'the breath, the soul, the understanding,' and its derivative *âtma-vant* means 'sensible,' 'self-controlled'; *âtman* is supposed to be derived from a root *ava*, *vâ*; with which compare the Heb. *hâvâ* 'to breathe.'

Fatu-ma-le-'ele'ele; 'seed-stone and earth.' *Fatu* is a word which, in various forms, is found in all Malaysia, Melanesia, and Polynesia, in the sense of 'hard,' 'anything hard,' 'the hard kernel or seed-stone of fruit.' For the meaning of *le-'ele'ele*, see above; but *Le-'Ele'ele* is here regarded as a woman, who, by the ordinance (*tofiga*) of Tangaloa is united (*fa'a-tasi*, 'joined,' *lit.* 'made-one') to *Fatu*, the completed man. *Fatu*

is the seed-giving principle, and Le 'Ele'ele is the receptacle of the seed. With this compare the tales in classic authors about De-méter ('Mother-Earth') and Zeus.

A void; 'va-nimo-nimo'; see note above. *To rest upon*; lit. 'to reach to.' All this corresponds with the Heb. 'tohu' (chaos) of creation,—a waste in which nothing was defined.

Region; itu, 'a side,' 'a district'; itu i mātū, 'the north'; cf. Heb. 'the sides of the north,' *yārekāthaim tzāphôn* (Isaiah xiv., 13) where *tzāphôn* is the region of 'darkness' (cf. Homer, *pros zophon*, Odys. ix., 25) 'the north quarter,' and *yārekāthaim* is a dual form to mean 'both sides,' hence 'the buttocks,' 'the back,' 'the remotest parts of a country.' This agrees with the idea conveyed by *tua-lagi* 'the back of the sky,' to which Lua'o and Luavai were appointed, to be regents there.

Fresh-water is 'vai.' In the 'Solo o le Va,' line 21, the creation of *vai* and *tai* is mentioned. The Polynesians believed that there were reservoirs of fresh-water up in the sky. In the Biblical account of the great Flood, it is said that 'the windows of heaven were opened.'

Le Fatu; see note above. *Ordains*; 'tofia'; cf. *ordinance*, 'tofiga.'

Points; *tusi*, 'to point out' with the index finger.

Masoa and *Teve* are both referred to in the 'Solo o le Va,' lines 73, 75. The *Masoa* (*Tacca pinnatifida*) is the arrow-root tree; growing on a succulent stem, with leaves only at the top, where they spread out like the surface of a round table. The *Teve* (*Tacca amorphophallus*) is another kind of arrow-root tree, very like the *Masoa*. From their shape, they are well fitted for the purpose to which they are applied in these myths. See also Sir Geo. Grey's "Polynesian Mythology."

There was nothing, &c.; 'a na leai se mea e taunu'ū i ai le va'ai.'

Far-receding sky; 'va-nimo-nimo.' See notes above.

21. *They brought forth*; the text has 'ua fanau Ao, toe fanau Po'; another reading is, 'ua fanau Po ma Ao, ua fa'a-tagata-ina ai le lagi,' 'they brought forth Night and Day, who caused-to-be-peopled the sky.' The order *Po ma Ao*, 'Night and Day,' is more consonant with the ideas of the Polynesians who counted by nights. The word *fa'atagataina* consists of *fa'a* the causative prefix already noticed, and *tagata*, 'man,' 'mankind,' which in another dialect is *kanaka*, now commonly applied to the 'labour-men' who are brought from the islands of the South Seas to the northern parts of Australia.

The eye of the sky; 'le mata o le lagi.' The Malays call the sun *mata-ari*, 'the eye of day.' The Egyptian City, On, (Heb. 'Ir-ha-Heres, Gr. Heliopolis) 'the city of the Sun,' got its name from Ain, Oin, 'the eye'—the emblem of the Sun.

The Second Heavens. Here the Polynesians believe, like other nations of old, that the sky originally lay flat on the earth, and covered it; by the aid of the *Masoa* and the *Teve*, Tui-te'e-lagi props it up, and this gives

room for Ilu and Mamao to work; this is the First Heavens; in it are placed the Sun and Night and Day. Ilu and Mamao then bear again, and the Sky ('le lagi'), according to the myth, is produced; this probably means the region above the clouds, for the Polynesian myth-makers must have noticed the difference between cloud-land and the higher sky; this Tui propped up, and it was the Second Heavens.

Remained there; i.e., in the Third Heavens, which they peopled. The heavens above the Third are, in the myth, produced (*fanau*) by Langi, the 'sky' personified, but they were all peopled by Ilu and Mamao. The notion that the stars in the heavens are gods and men and beasts and trees, &c., is a very old one.

22. *Tangaloa sat still.* In the 'Solo o le Va,' he is represented as a quiet, contemplative god, who delights in tranquillity and peace—the Polynesian Brahmā, the origin and source of all things. In his active manifestations he is *fa'a-tutupu-nuu* (see notes on *par.* 13), 'the creator of lands'; but in his dealings with men, he works by intermediary emanations from himself, which are all of them persons and called Tangaloa; *le fuli* is the 'immoveable' (*le* 'not,' *fuli*, 'to turn over,' 'to capsize'); *asi-asi-nu'u*, 'the omnipresent' (*asi*, 'to visit'; *asi-asi*, a frequentative; *nu'u*, 'a district, a country, a people'); *tolo-nu'u*, 'the extender of lands, or peoples' (*tolo*, 'to spread out'; it applies to reefs that run out into the sea, branches that spread out from the tree, or roots running along on the surface of the ground); *sāvāli*, 'the ambassador or messenger' (*sāvāli* means 'to walk').

Tuli and *Longonoa* both mean 'deaf' or 'deafness,' but that meaning cannot apply to these workers of Tangaloa. In the 'Solo o le Va,' Tuli is the bird-*'ata*' or emblem of Tangaloa; so also here, I believe. As to Longonoa, the simple verb *logo*, means 'to report'; hence I take Longonoa, to be 'the reporter,' the one who carries tidings up to Tangaloa; *logonoa* means 'to hear,' and *logo-logoā* is 'famous, renowned.' *Logonoa* would thus be used as a verbal adjective; and in form it corresponds with such verbs as *tala-noa* from *tala*. The Longo-noa here may be the same as the Rongo of other islands.

24. *They should go up.* The context means that Sāvāli, 'the messenger,' was sent down to summon a *fono* or council of the gods whose stations had been appointed in the various heavens below, and tell them that *they should go up* to the Ninth Heavens to deliberate there. This was a council of chiefs, for these gods are called *ali'i*, 'chiefs.' The *fono* determined to send Sāvāli down with a message to Night and Day.

25. *Langi-uli*, 'the dark, cloudy heavens'; *Largi-mā*, 'the bright clear heavens,' called also *Langi-lelei* (*lelei*, 'good, beautiful'). *Uli* means 'black,' 'dark blue.'

26. *Last injunction; mavaega*, 'a parting command.'

27. *Manu'a* and *Samoa*. The pride of race comes in here; Manu'a is the child of Night and Day, and is the brother of the Sun and Moon.

The ruler of the 'Celestial Empire' even cannot claim a more ancient lineage than that!

28. *Sa-tia-le-moa*. On this fabulous account of the origin of the names. Sāmoa and Manu'a, Mr. Powell's MSS. have this note:—"This affair of the names is in a very confused state. A man, Taua-nu'u, who is 'keeper of the traditions' for Taū, told me lately that Tangaloa fell from a precipice on to Malae-a-Vavāu, and was badly wounded, and from that circumstance Tau was called Manu'a tele, 'greatly wounded.' Several persons told Mr. Pratt and myself, in 1862, that the whole group is named Sāmoa, from Moa, the family name of the present King of Manu'a—Sā-moa or Sā-moa-atoa. Fofu and Taua-nu'u still maintain that the account given to Mr. Pratt and myself is perfectly correct, and that *le atu o Moa* ('the Moa group') includes Samoa, Tahiti, &c., &c."

29. *You two also*; i.e., the father and the mother with their four boys.

Malae-a-toto'a. It is a peaceful region, a land of rest and tranquillity; it is the glassy empyrean, beyond the reach of storms.

30. *Builders*; 'tūfūga.' See the 'Solo o le Va.'

Bright house. This paragraph seems to mean that the palace in the Ninth Heavens was not their work, although they built in all the heavens below. *Fale-ula* is the 'bright house'; *fale*, 'a house,' *ula*, 'red,' 'joyful,' 'bright'; hence the name means 'house of joy,' or 'the house beautiful.'

Offspring of Fatu and 'Ele'ele. All the children of Earth are placed under the command of these two chiefs, Manu'a and Sāmoa.

Tail of the names. Chiefs often have the name Tangaloa as the last part of their own names.

Tui, &c., 'king of Great Manu'a and all Sāmoa.' *Tui* also means 'king,' 'high chief.'

32. *Follow*. The sun and the moon are not here the cause of day and night; they only follow them. The day breaks, then comes the sun; darkness falls, and ere long the moon rises.

Shades; *ata*, 'shade,' 'emblem.' The '*ata*' or 'spirit' of Tangaloa resides in them, as in the Tuli; see note on *par.* 22.

Portion of the heavens; *itu*, 'side,' see notes on *par.* 20. The moon and the stars always pass along the sky in the same direction.

33. *Went to and fro*; 'fe-alu-alu-mai'; cf. notes on *par.* 13. *To visit the lands*; 'asi-asi i nu'u.' Here Savali performs the functions of *Tangaloa asi-asi nu'u*, another manifestation of the supreme god; in visiting these lands he assumed the form of the Tuli; cf. the 'Solo o le Va.'

The Eastern groups; that is, Tahiti and the adjacent islands.

The space between; '*vasa*,' that is, the ocean-space between two islands.

Walk it; '*savali*,' in allusion to his name.

Turned his face; *fa'asaga*, 'to direct to,' 'to face to.'

The Tongan group; which is placed as a stepping-stone between the Eastern group and Fiji. *That land*; 'lau-ele'ele'; see notes on *par.* 13.

34. *This Manu'a*; the land of the poet's birth.

Move about; 'fe-alu-mai,'—not the frequentative form this time. The meaning is that Manu'a was too small an island, and so the land ('lau-ele'ele) of Savai'i was created. Therefore, in poetry, these two islands are regarded as proceeding from the same act of creation.

35. *Got countries*; nu'u, 'lands.' Tangaloa, the supreme god, now goes down to examine the lands just created. Cf. "And behold every thing that he had made was very good." *Delighted in them*, 'fia-fia,' intensive; *said*, 'fetala'i,' a chief's word.

Black cloud; 'ao-uli-uli'; this is not a rain-cloud; in the book of Isaiah (c. iv., 5), the day-cloud, which is a manifestation of Jehovah's presence, a cloud of smoke ('*anân v'ashân*); cf. also 1 Kings, viii., 10.

Trample upon; 'soli-soli,' reduplication. As man is now about to come on the scene, the supreme god prepares the land for him to dwell in and to cultivate.

People to possess; *lit.*, 'people to people,' tagata e fa'a-tagata.

Atu-sasae; 'atu' means 'group,' and 'sasae' means 'eastern.' *Atu*, *Sasae*, Fiji, Tonga, are all personified here and become mythical personages. Here, as elsewhere, Fiji, although Melanesian, is included in the realms of Tangaloa, the Eastern God.

38. *Valu'a and Ti'apa*; these heroes are celebrated in another *Solo*.

I'i and Sava; a myth to account for the name Savai'i. Mr. Powell's notes add:—"Such is the account given me by Tauā-nu'u of Manu'a, the legend-keeper (Oct. 21, 1870). He also stated that Fatu and 'Ele'ele were the first pair who came from heaven; they came down at a place called Malae-a-Vavau, near the east end of the village of Taū; they gave birth to a boy and a girl named Tia'pa and Valu'a, who went and peopled Savai'i; for they became the parents of a girl named I'i and a boy Sava; hence the name Savai'i."

This side of the world; 'lenei itu lalolagi.'

39. *As if he were making a prayer*; 'peiseai se talo-talo ua fai'; *talo-talo* is an intensive reduplication of the verb *tatalo*, 'to pray'; *talo-saga* is 'a prayer'; *talo* means 'to make signs to,' 'to beckon'; hence 'to stretch out the hands in prayer.'

Land of Upolu; *Tutuila*; 'land' here is lau-ele'ele, not nu'u.

To rest; *malolo*, 'to be quiescent,' 'to rest,' not 'to rest from work'; *lands*, 'nu'u.'

40. *The Peopling Vine*; *le Fua-tagata*; cf. the '*Solo o le Va*,' (note 16). Evidently this vine has some connection with the Sun.

A council ground, that is, a *malae*.

Was walking; *eva-eva*, not *fe-alu-alu-mai*; *eva* means 'to walk by moonlight,' 'to walk or go about leisurely.' His work was done, and so he could now take a stroll, for recreation.

Shred them; 'totosi'; *tosi* means 'to tear in strips,' though not so as to separate; 'to draw out'; 'to form.'

Four persons; a myth to account for the names Upolu tele and Tutuila.

Fue-sā, 'the sacred climbing-vine.' Here called also *Fue-tagata*—an additional particular, not mentioned in the 'Solo o le Va.'

Flat lands; *lau-ele-ele*. *Parting command*; 'mavaega.'

42. *Show respect to*; 'le sopoia'; *lit.*, 'do not pass over.'

Do as he likes; *pule*, 'have authority and full control.'

43. As is usual, the poet, at the close of his tale, enforces the claim of Manu'a to have glory and honour.

ADDENDUM.

The Mexican story of Creation may be compared with this Polynesian 'tala'; I therefore quote a few points of resemblance from a French translation of the "Codex Ramirez," which was written in Spanish soon after the conquest of Mexico:—"The first god and the first goddess were self-created and dwelt in the Third Heavens; of their four sons, one was born red, another was born black.* Two of these sons, by appointment, proceeded to create first fire, then a half-sun, then a man and a woman, then the days, then a great fish* like a cayman, out of which they made the earth. As yet there was no division of time into years; so the creating gods now made a full sun to shine on the earth. Then great giants were made who lived only on acorns and could carry trees in their hands. Soon after, it rained *so much that the sky fell down upon the earth. The gods then created four men to help them to raise the sky again, and two of the gods changed themselves into trees* for the same end. The sun now resumed his place in the sky, and, in order that he might have hearts to feed on* and blood to drink, men were compelled to engage in perpetual war. One year after this, one of the four gods took a rod and with it struck a rock from which sprang the 'mountaineers,' who occupied the country before the Mexicans came there."

In the introduction to this 'tala,' I have offered a new derivation of the name Tangaloa. I wish now to add that that derivation has some support from what we know as to the Vedic god Varuna—the same word as the Greek *ouranos*, 'heaven.' The name Varuna is derived from the Sanskrit verb *vri*, 'to cover,' 'to surround'; and, in its compounds, 'to enclose,' 'to overspread'; a participial noun from it means 'a wrapper,' 'a cloak'; with these compare the Polynesian words already cited. In the Veda, Varuna is one of the most ancient of deities; he is sprung from 'Space,' and is the god of the heavens; in some of the later hymns, he

* Parallels to these are found in others of our Samoan myths

is regarded as controlling the waters, both in heaven and on earth; hence in the later mythology, his name is synonymous with 'the waters,' 'the ocean.' For, just as the Vedic Varuna covers and encompasses the terrestrial sphere, so the Homeric mighty river Okeanos surrounds the whole of the terrestrial lands. With all this compare the functions of Tangaloa, who, in some localities in Polynesia, is also lord of the sea.

In the Greek mythology, Ouranos is the grandfather of Zeus, and Varuna is thus more venerable and ancient than Dyaus, the lower sky.

ARTESIAN WATER IN NEW SOUTH WALES.

(Preliminary Notes.)

By Prof. T. W. EDGEWORTH DAVID, B.A., F.G.S.

[*Read before the Royal Society of N.S. Wales, November 4, 1891.*]

INTRODUCTION.—The waterless character of the greater portion of the vast interior of Australia, as well as the absence of any great inland ranges commensurate with its immense superficial area is a subject, which has been much dwelt upon in the narratives of Australian explorers. Obviously the former want is chiefly a consequence of the latter. Three conditions are usually necessary for maintaining a good water supply, viz., (1) abundant evaporation in the surrounding ocean; (2) carriage of the vapour-laden air inland by suitable winds; (3) condensation of the vapour by elevated areas of cold ground. Of these conditions the first is tolerably well fulfilled in Australia, but the second only partially so, and the third not at all, as far as relates to Central Australia. Exact observations have not yet been made over a sufficiently wide area to admit of an estimate being formed of the average rate of evaporation taking place in the ocean surrounding Australia, but probably it cannot be less than about a yard a year. Consequently, if the whole of the water-vapour withdrawn by

evaporation from an area of ocean only equal to that of Australia were carried uniformly over that continent and were condensed uniformly upon it there would be an annual rainfall everywhere throughout Australia of about thirty-six inches, but as a matter of fact there are large areas in Central Australia where the annual rainfall does not exceed ten inches, and in places falls as low as five inches, the latter being the average at Lake Eyre. This deficiency of rainfall in Central Australia is due partly to want of winds blowing inland from the ocean, but chiefly to the absence of high ranges in the interior to serve as condensers.

As regards want of suitable winds, Professor R. Tate, of Adelaide University, remarks*:—"The aridity of Central Australia is a consequence of its geographical position in reference to the region of low barometric pressure, being the co-ordinate region of high barometric pressure." This condition would obviously lead to the prevalent winds in Central Australia blowing outward in a north-westerly direction and would so check the advance inland of any winds blowing from the Tropics. The south-east trade winds, it is true, carry large quantities of moisture inland along the eastern coast of Australia, but an undue share of this is condensed and abstraced by the Cordillera, and after passing the latter owing to the absence of any more high ground to keep the air cold the moisture suspended in the form of clouds at the top of the Cordillera is re-evaporated, as it moves further westward, simultaneously with the re-heating of the wind as it descends to the level of the western plains, over which it then sweeps as a dry wind. From the Tropics also moisture is carried over a large portion of Australia by the north-west return trade wind. The altitude however, at which this wind blows, is so great that it is above the reach of the condensing influence of any but the highest ground in Australia.

These are a few of the causes, which conspire to make the rainfall in the central portion of Australia so much lower than it is in other countries situated in similar latitudes in the Southern

* Proc. Austr. Assoc. Adv. Science, Vol. I., p. 321.

and Northern Hemispheres. These facts show that the impression which has become somewhat popular, that Australia has as extensive a supply of fresh water underground as other countries in similar latitudes have above ground must be incorrect. These underground supplies are entirely dependent on the rainfall, and the average amount of water which might be annually drawn from this source could not, therefore, exceed the average quantity of rainfall which annually percolates into the water-bearing beds below ground. In spite of the scantiness of its rainfall Central Australia is not a desert, but may be described as a succession of plains and tablelands with isolated flat topped hills, mostly grassed or covered with shrubby salsolaceous plants or spinifex, but partly consisting of stony downs and ridges of rolling sand almost bare of vegetation excepting in the wet seasons. The two last mentioned varieties of country form however only a very small proportion of the whole. It may be possible in the future to so improve certain localities in this central area by means of storage of the surface water and use of the underground supplies, as to make them habitable and useful not only for pastoral but also to a limited extent for agricultural purposes, but anything like a wholesale reclamation of it and rendering it suitable for agriculture by either of the methods quoted above appears at present impracticable, as about twenty inches of rain are needed annually for irrigation, whereas the rainfall over a large area of Central Australia, as already stated, is only from five to ten inches.

ARTESIAN WATER IN OTHER COUNTRIES.—Before proceeding to describe the artesian water supply of Australia and especially of New South Wales, the Author wishes to draw attention very briefly to a few facts about the artesian water supplies of other countries, which may have a bearing upon that of our own. In the Anglo-Parisian Artesian Basin the supply of the artesian water has been proved to be directly dependent upon rainfall and to be liable to diminution if the supplies drawn from the basin are in excess of what the water-bearing strata receive by percolation. The great number of wells in the London Basin has had the effect

of reducing the flow of artesian water to such an extent that bores, which were flowing a few years ago, have now to be pumped.

At Kissengen in Bavaria, there is a remarkable salt well one thousand eight hundred and seventy-one feet deep, from which the water rises fifty-eight feet above the curb. The pressure of the water is attributed to carbon dioxide generated by the chemical reactions of sulphate of lime and limestone, a considerable thickness of both of which was passed through in boring the well.

In the United States of America the principal artesian basins are located as follows :—

- (1) Between the Sierra Nevada and the Pacific Ocean.
- (2) Between the Rocky Mountains and the Sierra Nevada.
- (3) On the East side of the Rocky Mountains.

In an area eighteen miles by fourteen miles in Kern County, California, fifty-four of the principal wells yield as much as 61,970,000 gallons of water daily.

In the San Luis Valley near the head of the Rio Grande, in an area measuring seventy miles by eighty miles there are as many as 2,000 artesian wells.

The result of the sinking of this vast number of successful wells has been that what was formerly an arid desert receiving only from two inches to six inches of rain annually is now being brought steadily under irrigation and cultivation. The value of land has in some instances been increased from fifty to two hundred and fifty per cent., and it is stated that wheat grown with artesian water in the Antelope Valley, Mogave Desert, took the first prize at one of the recent Agricultural Competitions in West California. It is however considered questionable whether artesian water, which is costly to secure, can be used profitably for grain raising. There can be no doubt however that it can be applied successfully to the raising of fruit and vegetables.

In America much importance is attached to the aeration of artesian water before it is allowed to enter the irrigation ditches, with the object presumably of converting soluble sulphates in the

water into carbonates, and so bringing about their precipitation and removal from the water, if the minerals forming them are hurtful to plant life. Such aeration is effected by allowing the water to flow from the mouth of the bore into a circular tank three hundred feet across and from two to three feet deep.

The origin of this artesian water in the United States on the east side of the Rocky Mountains is evidenced by the following facts. The rainfall of the Mississippi River Basin amounts to six hundred and twenty cubic miles of water annually. Of this total one hundred and seven cubic miles are annually discharged into the Gulf of Mexico. There remain therefore five hundred and thirteen cubic miles of water to account for. As not more than forty per cent. of the total rainfall is lost by evaporation, about two hundred and sixty-five cubic miles of water out of the total six hundred and twenty cubic miles produced by the annual rainfall must percolate, and so form what the American Geologists term the underflow, undersheet, or phreatic water, which constitutes the source of supply for the artesian and sub-artesian wells.

ARTESIAN WATER IN AUSTRALIA.—This is of two kinds. (*a*) natural, and (*b*) artificial.

(*a*) Natural artesian water rises to the surface in many parts of the east-central portions of Australia from mud or mound springs. These occur chiefly in strata of Cretaceous age. In Lower Cretaceous time, the eastern portion of Australia, comprising the Cordillera and a strip of country about one hundred miles in width on either side of it, was probably completely isolated by ocean from the Gulf of Carpentaria southerly, either to the Australian Bight, or to the Coorong Coast near the mouth of the Murray River, or perhaps in both these directions. If the latter was the case a triangular area of older rocks extending from near Mount Browne through the Barrier Ranges to Mount Lofty, near Adelaide, and thence to the Gawler Ranges must have been isolated from Eastern Australia, and so formed a large island between the latter region and West Australia. The question as to whether the Cretaceous Ocean ever extended across Australia to the Coorong, from the

Gulf of Carpentaria, in the direction of the present course of the Darling-Murray has not yet been definitely settled, owing to the thick covering of Tertiary beds, which completely hide from view the Cretaceous sediments from Dunlop Station, between Bourke and Wilcannia, to the mouth of the Darling-Murray.

With regard to the possible former extension in this direction of the Cretaceous Ocean my late colleague Mr. William Anderson remarks* :—"Between Bourke and the Barrier Ranges there occur at intervals series of isolated north and south ridges formed of Silurian and Devonian rocks, which crop out through the Cretaceous-Tertiary plains. It is more than probable that, somewhere in the area just mentioned, the Tertiary beds overlie and thin out northwards over the southern edges of the Cretaceous strata, because in a bore on Dunlop Station, between Bourke and Wilcannia, fossils have been identified by my colleague, Mr. R. Etheridge, as being undoubted Cretaceous forms, while at Lake Speculation, near Menindie, fossiliferous beds occur, from which fossil leaves have been obtained of Tertiary age. It is therefore reasonable to suppose that such an overlapping of the two formations occurs—the Tertiary plains being continuous in a northerly direction with the Cretaceous plains of Queensland, unless indeed Palæozoic ground having an east and west trend exists, which does not come to the surface, but which would produce a shoaling of the Tertiary formation on its southern side, and of the Cretaceous formation on the north side of it. It is just possible however that the superficial clays met with in the Dunlop bores, and passed through before meeting with the Cretaceous beds in many wells towards the Queensland border may represent the thinning out northwards of the Tertiary formation." All that can be said definitely at present, is, that as far as at present proved no Cretaceous fossils have been found along the tract of country described following the course of the Darling-Murray, anywhere to the south-west of Dunlop Station. It is just possible therefore that the Cretaceous Ocean covering the central portions of Australia was

* Ann. Report Depart. of Mines, 1891, *in lit.*

shut off on the south-east by a continental area of Palæozoic and Lower Mesozoic rocks extending from the Gawler Ranges to Mount Lofty and through the Barrier Ranges to Cobar and thence to the Cordillera of New South Wales. The only other direction by which the Cretaceous Ocean extending southerly from the Gulf of Carpentaria might have joined the Southern Ocean would have been by way of Lake Eyre, extending to the south of the Musgrave Ranges and lying to the west of the Gawler Ranges. On the east this ocean was bounded in the Australian area by the present main line of water-parting between the sources of the Flinders, Thompson, Barcoo, Warrego, Condamine and Darling (or Barwon) Rivers, and by the foothills on the edge of the Western Plains of New South Wales from near the Queensland border as far south as Narromine. The western boundary of this ocean is not known, but it was probably shut in by the Cloncurry and Musgrave Ranges and areas of rocks older than the Cretaceous extending from the latter locality to some point between Eucla and Cape Arid.

Mud springs or mound springs exist over a large portion of the area once occupied by this Cretaceous Ocean. The principal localities known to me are as follows:—

New South Wales—Wee-Watta, Cuddie Springs, Mulyeo.

Queensland—Several remarkable groups on the Lower Flinders; on the Einasleigh River; and between Hungerford and Thargomindah.

South Australia—In numerous spots over the great low-lying plain, into which drain the rivers Diamantina, Cooper, Macumba and Neales, and within which lie Lakes Eyre, Blanche and Frome.

Victoria—It is doubtful whether any natural mound springs exist in this Colony, though the Author is informed by Mr. H. C. Russell, F.R.S., the Government Astronomer of New South Wales, that it has been reported to him that the water, which usually lies in the extinct craters of Lake Albert and Lake Leake, near the boundary of Victoria, in South Australia, occasionally undergoes variations of level, which are independent of evaporation, or of the

waters received by the craters from rainfall. If this be a fact, it would tend to confirm the supposition that there are artesian water beds under the Tertiaries in this locality, the pipes of the volcanoes perhaps forming natural wells for the upward passage of the artesian water.

The mound springs of East-Central Australia often occur along the junction line of "bed-rock" with the Cretaceous strata, the water probably finding an easier outlet to the surface along this line owing to the sediments composing the Cretaceous Beds becoming coarser as they approach the bedrock, which formed the margin of the Cretaceous Ocean. The mud springs of South Australia, as described by Mr. H. Y. L. Brown, F.G.S., frequently form accumulations of travertine attaining heights of from forty to fifty feet above the level of the plain, and when occurring in groups, presenting the appearance as seen from a distance, of a low range of hills.

Perhaps the most remarkable groups of mud springs in Australia are those on the Lower Flinders, of which an excellent description has been given by Mr. E. Palmer, M.L.A.* As described by him, these springs are analogous to those between the Warrego and Bourke in New South Wales, and occur in clusters. Each cluster consists of a main or central spring surrounded by numberless ones of less importance, within a radius of a mile or so. The zone within which the clusters are situated trends north-north-west and south-south-east, and has a length of eighty miles. The springs erupt thin mud and hot water intermittently, and so gradually build up around their orifices mounds of mud of a rudely crateriform shape. The mounds are coated with a whitish crust of soda. At Mount Browne, on the Lower Flinders several feet above the general level of the plain is a mud-spring mound covered with gigantic tea-tree (*Melaleuca leucodendron*), amongst the matted roots of which the hot water steams in clear shining crystal pools. At the top of the mound is a large basin of hot

* Proc. R. Soc. Queensland, 1884, Vol. I. part i. pp. 19-23.

water stated to be fathomless. The roots and branches of the tea-trees lying in this water become coated with a soft green vegetable substance, with air bubbles clinging to them. Innumerable small bubbles of carbon di-oxide are continually rising to the surface of the basin. The water is too hot to bear the hand in for any length of time, but when cooled is good for use and always bright and clear, and free from any taste, while that in the adjoining cold springs is extremely disagreeable. The temperature of the water in two of these hot springs at Mount Browne is 120° F. No change has been observed in the hot springs as regards level or temperature since 1865, when a cattle station was settled there by Mr. Gibson.

At times the pressure from below forces the thin crust apparently of hardened mud upwards, and a flow of thin brown liquid mud spreads about, sometimes in great quantities. In one of the springs at Mount Browne flakes of granite are forced up and lie on the surface. The following is an analysis by Dr. Walter Flight of the white incrustation from these mud springs:—

Water	...	...	...	...	27·793
Silica ...	...	...	...	...	0·600
Chlorine	...	...	...	...	3·369
Sodium	...	...	...	...	2·183
Carbonic acid	...	...	...	...	33·735
Soda ...	...	...	...	...	31·690

99·370

Mr. J. E. Carne, F.G.S., informs the Author that he has observed a number of mound springs between Hungerford and Thargomindah. They are composed of hardened grey sandy clay, and attain a height of from fifteen to twenty feet. Their summits are occupied by cup shaped depressions full or partly full of tepid water, in a state of slow movement, so that the water flows sluggishly over the tops of the mounds and accumulates in shallow reedy pools at their base. Numerous gas-bubbles were observed by him coming up through the water in the basins.

Mr. R. L. Jack, F.G.S., Government Geologist of Queensland, has given an interesting description of the hot mound springs on the Einasleigh River, Queensland. There are five shallow wells there, from which the water flows copiously, having a temperature only slightly below boiling point. The mineral deposited from these springs has formed a mound of calcareous tufa or travertine fifteen feet high and two hundred and sixty yards in circumference. The mound is terraced with successive basins or cups.

Mr. J. W. Boulton, Officer-in-Charge of the Water Conservation, Department of Mines, New South Wales, informs the Author that to the list of mud springs already given for New South Wales the following may be added:—Bingewilpa on Yancannia Station; Native Dog (or Courallie), Kullyna, and Lila Springs, on Bourke-Barrington Road; Youngerrina, Yantabulla, Warroo, and Boon-goonyarra on the Bourke to Hungerford Road; Peri Springs, and Goonery Springs.

REFERENCES.—The Author has to express his indebtedness to the following:—

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- (2) Anderson, William, Geological Surveyor—Water Supply of Broken Hill, Govt. Printer, Sydney—Annual Report Dept. of Mines, 1891.
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PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

—◆◆—

WEDNESDAY, MAY 6, 1891.

ANNUAL GENERAL MEETING.

Dr. LEIBIUS, M.A., F.C.S., President, in the Chair.

Forty members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ending 31st March, 1891, was presented by the Hon. Treasurer and adopted:—

GENERAL ACCOUNT.

				RECEIPTS.			£ s. d.			£ s. d.		
Subscriptions	{ One Guinea			...	...	...	217	7	0	612	1	0
	{ Two Guineas			...	...	...	356	18	0			
	{ Arrears			...	...	...	37	16	0			
Entrance Fees	...	...	...	...	...	...	...	...	...	46	4	0
Parliamentary Grant on Subscriptions received during 1890										500	0	0
Rent of Hall	...	...	...	...	...	...	...	...	...	103	1	0
Sundries	...	...	...	...	...	...	...	...	...	4	5	7
Total Receipts										1265	11	7
Balance on 1st April, 1890										44	11	5
										<hr/> £1310 3 0 <hr/>		
				PAYMENTS.			£ s. d.			£ s. d.		
Advertisements	...	...	...	...	...	...	41	8	0			
Assistant Secretary	...	...	...	...	...	...	250	0	0			
Books and Periodicals	...	...	...	...	...	...	152	14	3			
Bookbinding	...	...	...	...	...	...	93	16	7			
Carried forward										<hr/> £537 18 10 <hr/>		

PAYMENTS— <i>continued</i> .						£	s.	d.	£	s.	d.
Brought forward	...	...	...	...	...	537	18	10			
Conversazione	...	...	...	...	...	134	14	6			
Freight, Charges, Packing, &c.	...	...	...	...	...	27	9	10			
Furniture and Effects	...	...	...	...	...	28	6	10			
Gas	...	...	...	...	...	24	8	11			
Housekeeper	...	...	...	...	...	10	0	0			
Insurance	...	...	...	...	...	9	10	0			
Office Boy	...	...	...	...	...	4	13	4			
Petty Cash Expenses	...	...	...	...	...	8	17	6			
Postage and Duty Stamps	...	...	...	...	...	47	7	6			
Printing	...	...	...	...	...	31	0	9			
Printing and Publishing Journal	...	...	...	...	...	316	3	5			
Rates	...	...	...	...	...	22	18	4			
Refreshments and attendance at Meetings	...	...	...	...	...	16	18	0			
Repairs	...	...	...	...	...	16	7	9			
Stationery	...	...	...	...	...	1	18	0			
Sundries	...	...	...	...	...	29	17	6			
Total Payments	...	...	...	...	...	<hr/>			1268	11	0
Balance on 31st March, 1891	...	...	...	...	...				41	12	0
									<hr/>		
									£1310	3	0

BUILDING AND INVESTMENT FUND.

RECEIPTS.						£	s.	d.
Interest on Fixed Deposit	...	...	...	...	...	27	0	0
Amount of Fund on 1st. April, 1890	...	...	...	...	...	539	17	1
						<hr/>		
						£566	17	1
						<hr/>		
						£	s.	d.
Fixed Deposit in Union Bank	...	...	...	...	...	566	17	1
						<hr/>		
						£566	17	1

CLARKE MEMORIAL FUND.

RECEIPTS.						£	s.	d.
Interest on Fixed Deposit	...	...	...	...	...	14	6	0
Amount of Fund on 1st April, 1890	...	...	...	...	...	285	15	8
						<hr/>		
						£300	1	8
						<hr/>		
						£	s.	d.
Fixed Deposit in Union Bank	...	...	...	...	...	300	1	8
						<hr/>		
						£300	1	8

AUDITED, P. N. TREBECK.

ROBERT HUNT, *Honorary Treasurer.*

H. O. WALKER.

W. H. WEBB, *Assistant Secretary.*

SYDNEY, 20th April, 1891.

Messrs. H. A. Lenehan and D. M. Maitland were elected Scrutineers for the election of officers and members of Council.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year :

Honorary President :

HIS EXCELLENCY THE RIGHT HON. THE EARL OF JERSEY, G.C.M.G.

President :

H. C. RUSSELL, B.A., C.M.G., F.R.S.

Vice-Presidents :

PROF. LIVERSIDGE, M.A., F.R.S.

A. LEIBIUS, Ph.D., M.A., F.C.S.

W. A. DIXON, F.C.S., F.I.C.

H. G. A. WRIGHT, M.R.C.S.E., &c.

Hon. Treasurer :

ROBERT HUNT, C.M.G., F.G.S.

Hon. Secretaries :

F. B. KYNGDON.

PROF. WARREN, M. INST. C.E., WH. SC.

Members of Council :

ROBERT ETHERIDGE, JUNR.

T. EDGEWORTH DAVID, B.A., F.G.S.

CHARLES MOORE, F.L.S., F.Z.S.

J. A. MacDONALD, M. INST. C.E.

PROF. ANDERSON STUART, M.D.

J. H. MAIDEN, F.L.S., F.C.S.

C. S. WILKINSON, F.G.S., F.L.S.

ALEXR. MACCORMICK, M.D.

W. M. HAMLET, F.C.S., F.I.C.

C. W. DARLEY, M. INST. C.E.

The following gentlemen were duly elected ordinary members of the Society :—

Coutie, William Henry, M.B., Ch. B., Univ. *Melb.*; Petersham.

Hood, Alexander Jarvie, M.B., Mast. Surg. *Glas.*; Sydney.

Jordan, Rev. W., M.A.; Berridale, Cooma.

Selman, D. Codrington, Wh. Sc.; Sydney.

Smail, J. M., C.E.; Sydney.

The certificates of six new candidates were read for the second time, and of eighteen for the first time.

SECTIONAL COMMITTEES—SESSION 1891.

The names of the Committee-men of the different Sections were announced :—

CIVIL	{	Chairman ... Cecil Darley, M. Inst. C.E.
		Secretary ... Prof. Warren, M. Inst. C.E.
		Committee ... J. A. MacDonald, M. Inst. C.E., W. Shellshear,
ENGINEERING	{	A. M. Inst. C.E., H. Deane, M. Inst. C.E., J. B.
SECTION.		Henson, C.E.

Meetings held on the Second Wednesday in each month, at 8 p.m.

MEDICAL SECTION.	{	Chairman ... Prof. T. P. Anderson-Stuart, M.D.
	{	Secretaries... Dr. Hull and Dr. MacAllister.
	{	Committee... Dr. Fiaschi, Dr. Huxtable, Dr. Crago, Dr. James Graham, Dr. MacCormick, Hon. Dr. H. N. MacLaurin.
	{	

Meetings held on the Third Friday in each month, at 8.15 p.m.

MICROSCOPICAL SECTION.	{	Chairman ... H. O. Walker.
	{	Secretary ... S. MacDonnell.
	{	Committee... Dr. Wright, Dr. Huxtable, G. D. Hirst, F. B. Kyngdon, P. N. Trebeck, T. F. Wiesener.

Meetings held on the Second Monday in each month at 8 p.m.

One hundred and eighty-nine volumes, four hundred and thirty-seven parts, one hundred and forty-eight pamphlets forty-three meteorological charts, two hydrographic charts, three geological maps, two photographs and two micro-photographs received as donations since the last meeting, were laid upon the table and acknowledged.

The following letter was read from Prof. F. W. Hutton, F.G.S.:

Canterbury College, Christchurch, New Zealand,
24th December, 1890.

Dear Sir,—I find it difficult to express the pleasure given me by the announcement that I had been awarded the Clarke Medal by the Council of the Royal Society of New South Wales.

The scientific worker always looks with pleasure on work that he has accomplished, although mixed with that pleasure there is still a feeling that he may be too sanguine and overestimate his own work. But no shadow of doubt is mixed with the pleasure given by the receipt of a mark of approval from fellow workers, and this mark of approval is the greatest reward a scientific man can hope for.

Please convey to the President and Members of the Council my thanks and appreciation of the great honour they have done me.

Yours truly,

F. W. HUTTON.

The Hon. Secretary, Royal Society of New South Wales.

Dr. LEIBIUS, M.A., F.C.S., then read his address.

A vote of thanks was passed to the retiring President, and Mr. H. C. RUSSELL, B.A., C.M.G., F.R.S., was installed as President for the ensuing year.

Mr. RUSSELL, in replying, expressed his warmest thanks at the honour conferred on him in his re-election to the Presidential Chair. He earnestly wished that his other duties would enable him to render better service to the Society than he could under the circumstances. He was sure that he was only expressing the feeling of every member present when he conveyed to Dr. Leibius his warmest thanks for the very able address which he had just delivered, and for the ability and close attention which he had given to the duties of the office during the time he had been President—services which had tended materially to the benefit of the interests of the Society. He would like to call attention to the fact that the vitality of the Society, although it had shown signs of improvement during the past year, might still be increased, and he earnestly desired that the members would take steps to secure such a prosperity as would eclipse all efforts in the past.

WEDNESDAY, JUNE 3, 1891.

W. A. DIXON, F.C.S., F.I.C., Vice-President, in the Chair.

Thirty members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of six new candidates were read for the third time, of eighteen for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Amphlett, Edward Albin, C.E.; North Sydney.

DeBurgh, Ernest Macartney, C.E.; Ryde.

Fitzgerald, Robert D., C.E.; Hunter's Hill.

Houghton, Thomas H., A.M.I.C.E., M.I.M.E.; Sydney.

Jones, Robert Edgar, A.M.I.C.E.; Summer Hill.

Poole, William, Junr.; Redfern.

Eighteen volumes, one hundred and thirty-eight parts, and seven pamphlets, received as donations since the last meeting, were laid upon the table and acknowledged.

A paper was read "Notes on the large death-rate among Aus-

tralian sheep in country affected with Cumberland Disease or Splenic Fever" by M. ADRIEN LOIR.

Mr. CHARLES MOORE, F.L.S., F.Z.S., expressed his sense of the value of the paper. He was quite sure that Mons. Loir was right in his conclusions. It was no use burying the dead animals; they must be burned to prevent infection.

Professor ANDERSON STUART, M.D., considered that the thanks of the Pastoralists were due to the author of the paper, and thought that the suggestion of Mons. Loir, that the Pastoralists should take precautions to prevent the export of any infected carcasses, was an excellent one. If any of the microbes were found in Europe in meat received from Australia the fact would be sure to be made the most of by interested parties, and it would prove to be the death-knell to the trade.

The Hon. Dr. MACLAURIN, M.L.C., pointed out that the law already provided for the dealing with persons who sold diseased meat. He fancied that exporters would see that it would be not only wicked but foolish to send such meat to market. If they exported it they did so in contravention of the law.

EXHIBITS.

Demonstration of a new Machine for use in explaining the Nature of such Waves as those of Light, by Prof. ANDERSON STUART, M.D. The instrument, to which he had not yet given a name, showed the movements of pellets of ivory, which represented particles of air as they oscillated to and fro. The first idea which led him to construct the apparatus was obtained from the oscillation of the legs of the centipede, which moved in a double wave—as seen from above, in waves of condensation and rarefaction; as seen from the side, in vertical waves. The instrument was described as accurately representing the to-and-fro movement of the particles of air. The sound wave, as it were, could therefore be seen progressing from one end of the instrument to the other.

The Tintometer.—Mr. W. A. DIXON, F.I.C., F.C.S., exhibited this instrument as made by J. W. Lovibond of Salisbury, England.

The instrument is intended to analyse the colour of any substance either in solution or solid, by the use of coloured glasses accurately graded, into two of the primary colours red, yellow and blue with so much shade added. In his early trials the great difficulty was to get a colourless glass as a basis. Mr. L. first started with dark tints of the above three colours and took as his standard the least difference that could be seen between two glasses of the same colour which was called 1 for each; for lighter shades in which the perception of variation in colour is more readily noticed, this standard was divided into tenths and hundredths. Each of the three colours was so far treated independently until it was found that the mixture of these standards in the proportion of 1 of red 1.2 of yellow and 2.4 of blue produced a neutral grey at all depths of shade, until, with the deepest, blackness was the result. The standard was therefore altered so that 1 red, 1 yellow and 1 blue produced neutral grey, which made it possible to register any tint in terms of two colours plus so much grey. Thus in three of the coloured papers which I have to show you, the first a greenish-blue registers 2.5° yellow and 4.4° of blue simply—the second a dark crimson colour registers 16.5° red, 1.2° yellow, and 1° blue, and as 1 blue, 1 yellow and 1 red produces 3 of grey, the corrected reading is red 15.5° yellow 0.2° and grey 3° . In the third, which is pale yellowish-brown the tests show 2.5° yellow, 2.5° red, and 1.1° blue, so the corrected register becomes 1.4° yellow, 1.4° red, and 3.3° of grey.

The instrument itself consists of a tapering tube divided in two by a partition with an observing opening at one end, so that on looking through two oblong fields are seen together. Opposite one of these fields the object to be observed is placed and into slits in the tube slides of coloured glass are placed until equality is produced. In the case of fluids, cells from $\frac{1}{8}$ inch to 2 inches or more in depth are used; these have parallel sides as that the image is pure, and the light is obtained by reflection from a surface of opal glass; in diffuse daylight with opaque objects a tray of plaster of Paris is used as a reflector behind the coloured glasses.

The three colours in equal proportions give grey, *i.e.*, 1° red, 1° blue, 1° yellow. Now 1° red + 1° blue produce purple, 1° blue + 1° yellow produce green, 1° red + 1° yellow produce orange. For pure white as a back ground snow was taken as the standard, and it was found that pure plaster of Paris is 0·12° greyer than snow and Chance's opal glass faintly more grey. The observation is made with one eye only, as hundreds of trials showed that in but few cases was the colour perception the same with both eyes.

In case of any change taking place in the colour of the standard glasses there are various solutions by which the standard can be recovered as for example a column of distilled water for blue.

These instruments are now largely coming into use for colour determinations in malt, beer, wine, oils, dyes, and for the colourimetric determination of carbon in steel and ammonia in water. In the latter and some others, as flour, specially coloured glasses are used which give the reading directly, using one tint only.

WEDNESDAY JULY 1, 1891.

H. C. RUSSELL, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-five members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eighteen new candidates were read for the third time, of four for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Bowman, Archer S., C.E. ; Sydney.

Campbell, John Honeyford ; Sydney.

Chisholm, James Kinghorn, J.P.; Narellan.

Clarke, Gaius, C.E. ; North Sydney.

Dunstan, Benjamin ; Sydney.

Gill, Robert J., C.E.; Blayney.

Guthrie, F. B. ; Sydney.

Halliday, The Hon. William, M.L.C. ; Sydney.

Hedley, Charles, F.L.S. ; Sydney.

Hickson, Robert, M. Inst. C.E.; Bondi.

King, Christopher Watkins, L.S.; Sydney.

Seaver, Thos. Whitchurch, B.C.E. Roy. Univ. *Irel.*; N. Shore.

Stilwell, Arthur William, C.E.; Sydney.

Ward, Thomas William Chapman, B.A., B.C.E. *Syd.*; Sydney.

Watkins, Sydney C., M.R.C.S., *Eng.*; Manly.

Wells, Frederick, M. Inst. C.E.; Balmain.

Wilson, Robert Archibald, M.D., Mast. Surg. *Glas.*; Balmain.

Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*; Ashfield.

Nineteen volumes, ninety-eight parts and nineteen pamphlets received as donations were laid upon the table.

The following letters were read :—

Extract from a letter in German of Baron von Müller of Melbourne to Dr. Leibius, dated June 10, 1891, re “Antarctic Expedition &c.”

“ If private contributions are now very energetically collected the funds for obtaining two ships and their equipment may be considered as secured, especially as Sir Thomas Elder has, according to letters received by me within the last few days, taken a most generous interest in the undertaking. It is important that the funds should be collected—both the Government subsidy and private subscriptions—during this month (June) to enable us to telegraph through the Swedish Consulate at Melbourne, that at least £15,000 are actually secured for the equipment of two ships. Baron Nordenskiöld can then during July to October get his ships overhauled and make all other preparations during the Northern winter, so that the ships may start from Sweden next March, and be during next June in Australia, in August at Macquarie Island, and during September to February (1892-3) in the Antarctic sea. I hope to overcome any difficulties in New Zealand and South Australia. Western Australia has already made promises. . . . ”

The Chairman stated that the Secretary would be glad to receive any contributions the members had to give.

Windgidgeon via Gilgandra,

June 15, 1891.

Professor Liversidge, Sydney.

Sir,—I noticed in a recent issue of the *Sydney Mail* a notice in reference to the discovery of some caves (Aboriginal) in which were drawings of human hands &c. I know where there is another cave similar to the one mentioned in the paper. It is situated close to the Munghorn Gap which

gap is in the Main Dividing Range and on the road from Mudgee to Wollar. The cave is situated in an isolated freestone rock of mammoth size. We have generally known these as the "Red Hand Caves," as all the figures represented therein are in a red colour, supposed to have been coloured red with gum taken from the Apple Tree. If you should be desirous of finding the whereabouts of this cave I will give all the information in my power. There are also some more caves situated in Dunn's Mountain. This mountain is in the Dividing Range, situated to the south-east of Rylestone. When I noticed the paragraph I determined upon writing you *re* these mentioned, and trust the information will be of benefit.

I remain, yours sincerely,

W. G. COX.

The following papers were read :—

1. "On Nos. 13 and 14 Compressed-air Flying Machines" by
LAWRENCE HARGRAVE.
2. "Some Folk-songs and Myths from Samoa," translated by
the Rev. G. PRATT, with Introductions and Notes by JOHN
FRASER, LL.D.
Remarks were made by Prof. Threlfall, Mr. W. A. Dixon,
and the Rev. S. Wilkinson.
3. "On a Cyclonic Storm or Tornado in the Gwydir District,"
4. "Preparations now being made in Sydney Observatory for
the Photographic Chart of the Heavens," by H. C. RUSSELL
B.A., C.M.G., F.R.S.

WEDNESDAY, AUGUST 5, 1891.

H. C. RUSSELL, B.A., C.M.G. F.R.S., President in the Chair.

Forty members and six visitors were present.

The certificates of four new candidates were read for the third time, of four for the second time, and of thirteen for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Burge, Charles Ormsby, M. Inst. C.E.; North Sydney.

Firth, Thomas Rhodes, C.E.; Arncliffe.

Jamieson, Sydney, B.A., M.B., M.R.C.S., L.R.C.P.; Ashfield.

Sutherland, George W., M.D. *Lond.*, M.C. *Edin.*; Glebe.

Twenty volumes, eighty-one parts, eighteen pamphlets and one large mounted map received as donations since the last meeting, were laid upon the table and acknowledged.

The Rev. J. MILNE CURRAN, F.G.S., read a paper on the "Microscopic structure of Australian Rocks," which was illustrated by slides and photographs of rock sections shown by a projection microscope in connection with a triunial lantern; rock sections being likewise shown under the microscope.

After some remarks upon the same by Prof. David, B.A., F.G.S., the President on behalf of the Society, presented the Rev. J. Milne Curran with the Society's Medal and cheque for £25 which had been awarded to him for his valuable paper.

Prof. ANDERSON STUART, M.D., exhibited and described his new instrument for use in explaining the nature of such waves as those of light.

Rev. J. M. CURRAN exhibited a new 'Dick and Swift's' Petrological Microscope.

WEDNESDAY, SEPTEMBER 2, 1891.

H. C. RUSSELL, B.A., C.M.G., F.R.S., President, in the Chair.

Forty members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The PRESIDENT referred briefly to the great loss the Society had sustained by the death of Mr. C. S. Wilkinson, late Government Geologist.

The certificates of four new candidates were read for the third time, of thirteen for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Farr, Clinton Coleridge, B.Sc.; Sydney.

Grimshaw, James Walter, Assoc. M. Inst. C.E., M.I. Mech. E.; Sydney.

Parkinson, Henry W., C.E.; Berry, N.S. Wales.

Smith, George Francis, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*; Hamilton, New South Wales.

Nineteen volumes, one hundred and forty-two parts, fifteen pamphlets, one volume of photographs, and one atlas of maps, received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "On a wave-propelled vessel," by LAWRENCE HARGRAVE.
2. "Notes on a spontaneous disease among Australian rabbits," by M. ADRIEN LOIR.
3. "Notes on some celestial photographs recently taken at the Sydney Observatory," by H. C. RUSSELL, B.A., C.M.G., F.R.S.
4. "Some Folk-songs and Myths from Samoa," translated by the Rev. G. PRATT, with Introductions and Notes by JOHN FRASER, LL.D.

Remarks were made by Messrs. C. Moore, W. M. Hamlet, Rev. W. Wyatt Gill, and the Chairman.

EXHIBIT.

"Rapid filtration without the aid of pumps," by WILLIAM M. HAMLET, F.I.C., F.C.S., Government Analyst.—In the ordinary method of filtration a disc of filter paper is folded in quadrants, and the cone of paper opened out into a funnel for its support, In this way half the area of the filter consists of one thickness of paper while the other half is composed of three thicknesses of paper—a decided drawback and disadvantage in quick filtration. Mr. Droop Richmond, suggested a new mode of folding the filter. The disc is first folded in two as in the ordinary way, then opened out and folded at right angles into two similarly equal halves. The disc is again opened out and turned over and a third fold made so as to equally divide any two opposite quadrants. Thus there are two folds on one face of the paper and the third fold on the other face. By drawing the folds up into a cone an equal distribution of the folds is obtained and the objectionable triple thickness of the old filter done away with. In order to keep the fold upright after moistening with water, Fessenden (Chem. News Vol. LX. p. 102) proposed a V-shaped central support to be used

with a funnel. Gyzander, (*Ibid.*, Vol. LX. p. 167) abolished the funnel altogether, substituting a wire support which he suspended from a hook. An improvement upon this I exhibited to the members of the Royal Society whereby the suspension is done away with, and the filter made to stand on a table or over a common beaker. The improvement consists first in making the apparatus entirely of glass rod so that nitro-hydrochloric acid may be used, and in shortening one of the suspensory arms so as to allow of the better approach of the jet from a wash-bottle; and thirdly in fitting one of the arms to a clamp instead of suspending it from a hook as proposed by Gyzander. By the use of this contrivance the speed of filtration may be hastened four or five fold, and there is not much difficulty in making them.

WEDNESDAY, OCTOBER 7, 1891.

H. C. RUSSELL, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-five members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of thirteen new candidates were read for the third time, of three for the second time, and of eight for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Boys, J. W. T., Assoc. M. Inst. C.E.; North Sydney.

Bruce, John Leck; Sydney.

Edwards, Charles Augustus, L.R.C.P., L.R.C.S., L.S.A.; Waverley.

Hanly, Charles, L.S.; North Sydney.

Haviland, Edwin Cyril; Sydney.

Hutchinson, William, Assoc. M. Inst. C.E.; Sydney.

Lenthall, R. E., C.E.; Waverley.

McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*;
Gladesville.

McKay, Robert Thomas, L.S.; North Sydney.

Noble, Edwald George, Paddington.

Osborn, A. F., Assoc. M. Inst. C.E.; Cowra.

Pridham, Theodore, Assoc. M. Inst. C.E.; Dulwich Hill.

Robjohns, Rev. Henry Thomas, B.A. *Lond.*, M.A. *Syd.*; Waverley.

Eighteen volumes, one hundred and twenty parts, seventeen pamphlets, and fifteen meteorological charts received as donations since the last meeting were laid upon the table and acknowledged.

The following papers were read :—

1. "Notes on the use, construction, and cost of service reservoirs in New South Wales," by C. W. DARLEY, M. Inst. C.E.
2. "Some Folk-songs and Myths from Samoa," translated by the Rev. G. PRATT, with Introductions and Notes by JOHN FRASER, LL.D.

WEDNESDAY, NOVEMBER 4, 1891.

H. C. RUSSELL, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-one members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of three new candidates were read for the third time, of eight for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Dickinson, T.; Sydney.

Shaw, Percy William, C.E.; Sydney.

Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C.E.; Newcastle.

Eleven volumes, eighty three parts, and five pamphlets, received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "Artesian Water in New South Wales"—Preliminary Notes by Prof. T. W. E. DAVID, B.A., F.G.S.
2. "On the constitution of the Sugar Series," by W. M. HAMLET F.C.S., F.I.C.

WEDNESDAY, DECEMBER 2, 1891.

H. C. RUSSELL, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-five members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of eight new candidates were read for the third time, of one for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society :—

Brennand, Henry J. W. ; Stanmore.

Campbell, William Dugald, Assoc. M. Inst. C.E., Assoc. King's Coll. Lond., F.G.S. ; Sydney.

Carment, David, F.I.A. *Gt. Brit. and Irel.*, F.F.A. *Scot.*; Sydney.

Curran, Rev. John Milne, F.G.S. ; Redfern.

Despeissis, Jean Adrian, M.R.A.C. ; Sydney.

How, William F., Assoc. M. Inst. C.E., M.I. Mech. E., Wh. Sc. ; Sydney.

Pringle, Adam Thompson ; Concord.

Tooth, Alfred Erasmus ; Homebush.

It was resolved that Messrs H. O. Walker and S. MacDonnell be appointed Auditors for the current year.

Eighteen volumes, one hundred and forty-four parts, sixty-one pamphlets and seven hydrographic charts, received as donations since the last meeting, were laid upon the table and acknowledged.

The following papers were read :—

1. "On Kaolinite from the Hawkesbury Sandstone," by HENRY G. SMITH.

Remarks were made by Messrs. J. F. Mann, W. A. Dixon and C. Moore.

2. "On some New South Wales and other Minerals," (Note No. 6) by Prof. LIVERSIDGE, M.A., F.R.S.

3. "Notes on the rate of growth of some Australian Trees," by H. C. RUSSELL, B.A., C.M.G., F.R.S.

Remarks were made by Messrs. C. Moore, J. F. Mann, D. M. Maitland, Hon. L. F. DeSalis and Mr. C. Hanley.

4. "Some Folk-songs and Myths from Samoa," translated by the Rev. G. PRATT, with Introductions and Notes by JOHN FRASER, LL.D. This paper was the conclusion of a series of papers on the same subject.

The CHAIRMAN, in closing the meeting, said that the present session which was now closing had been the most successful session for some years past. The average attendance of members at the meetings had been thirty-six, whereas some time ago it had been as low as nineteen, and in the past difficulty had sometimes been experienced to obtain a quorum. Another important point was that during the session the average attendance of visitors had been four. During the year sixty-four new members had been enrolled, and the membership, including the candidates' certificates that had been read for the first and second time, had now reached four hundred and ninety-four, and, as they were aware, the limit was five hundred members. In closing the session he cordially thanked them for the kindness shown to him whilst chairman, and felt sure that the same kind treatment would be received by his successor.

PROCEEDINGS OF THE SECTIONS

(IN ABSTRACT.)

CIVIL AND MECHANICAL ENGINEERING SECTION.

At the preliminary meeting held in April, the following officers were elected :—Chairman : Mr. CECIL DARLEY, M. Inst. C.E. Hon. Secretary : Professor WARREN, M. Inst. C.E. Committee: Mr. J. A. McDONALD, M. Inst. C.E., Mr. H. DEANE, M.A., M. Inst. C.E., Mr. W. SHELLSHEAR, A.M. Inst. C.E., Mr. HENSON, C.E.

Monthly meeting held May 13, 1891.

Mr. C. DARLEY, in the Chair.

The CHAIRMAN delivered an address in which he defined the aims and objects of the Section with regard to papers to be read and discussed, which should consist of the following :—

1. Descriptive accounts of works carried out with full details of cost, difficulties met with and overcome.
2. Researches on the strength and durability of materials of construction, more particularly with regard to the materials available for use in the various portions of this Colony.
3. Records of failures and their causes.

The Chairman also referred to the professional training of Civil Engineers, and urged the importance of the course of instruction provided by the University of Sydney in the Engineering School as a basis for future professional work.

Professor WARREN read a paper on “Recent researches on the Strength, Elasticity and Endurance of Materials of Construction with especial reference to Iron and Steel. Considerations with reference to the determination of the Safe Working Stresses in Structures.”

The following gentlemen took part in the discussion, Mr. J. A. McDonald, Mr. Deane, Mr. Houghton, Mr. Shellshear, Mr.

Henson, Mr. Selman, Mr. Dare, Mr. Vicars, Mr. Parkinson and Mr. Haycroft.

Monthly meeting held June 10, 1891.

Mr. H. DEANE, in the Chair.

A paper was read by Mr. H. DARE, B.C.E., on "The bridge over Lane Cove River at the head of the navigation."

The following gentlemen took part in the discussion, Colonel Wells, Mr. Vicars, Mr. Haycroft, Mr. Allen, Mr. Smail, Mr. Deane, Mr. De Burgh.

Monthly meeting held July 8, 1891.

Mr. C. DARLEY, in the Chair.

The evening was devoted to a further discussion of Mr. Dare's paper which was opened by Mr. De Burgh ; the Chairman took part in the discussion and Mr. Dare replied.

Monthly meeting held August 12, 1891.

Mr. C. DARLEY in the Chair.

A paper was read by Mr. HAYCROFT, M.C.E., "on the Calculation of Stresses by means of Graphic Analysis."

Monthly meeting held September 9, 1891.

Mr. C. DARLEY, in the Chair.

The evening was devoted to the discussion of Mr. Haycroft's paper, which was opened by the Secretary reading Mr. Parkinson's contribution, which was followed by remarks from Mr. Grimshaw, Professor Warren, Mr. Vicars, and the Chairman.

Monthly meeting held October 21, 1891.

Mr. C. DARLEY, in the Chair.

A paper on the "Use, Construction, and Cost of Service Reservoirs in New South Wales," by C. DARLEY, M. Inst.C.E., had previously been read at the General Monthly Meeting, printed and distributed among the members of the Engineering Section.

The evening was devoted to the discussion of Mr. Darley's paper in which the following gentlemen took part :—Mr. Trevor Jones, Mr. McDonald, Mr. Grimshaw, Col. Wells, Mr. Smail, Mr. Houghton, Mr. Vicars, Mr. Self, Mr. Haycroft. Mr. Darley replied to the various questions raised during the discussion.

Monthly meeting held November 18, 1891.

Mr. C. DARLEY, in the Chair.

A paper on the Tacheometer and its application to Engineering Surveys prepared by Mr. WM. POOLE, Junr. was read by Mr. Knibbs in consequence of the absence of Mr. Poole.

The following gentlemen took part in the discussion :—Mr. McKinney, Col. Wells, Mr. Madsen, Mr. Grimshaw, Mr. Knibbs.

Monthly meeting held December 16, 1891.

Mr. J. A. McDONALD, in the Chair.

A paper was read by J. ASHBURTON THOMPSON, M.D. *Brux.*, on "The Sewerage of Country Towns," which was discussed by Mr. Jones, Mr. Smail, Prof. Warren and Mr. Henson. It was agreed to continue the discussion on this important paper at the first meeting of the Section in May next.

MEDICAL SECTION.

At the preliminary meeting held in April, the following officers were elected :—Chairman : Professor T. P. ANDERSON STUART. Committee : Drs. P. SYDNEY JONES, W. H. CRAGO, L. R. HUXTABLE, The Hon. Dr. MACLAURIN, Drs. JAMES GRAHAM, and MACCORMICK. Secretaries : Drs. MACALLISTER and HULL.

During the session Prof. Stuart resigned his position of Chairman on account of his visit to Europe.

Four general meetings were held. At the first a paper was read by Prof. STUART, entitled "A brief account of the histology and development of tubercle." The lecture was illustrated by means of lantern slides.

At the second Dr. WILKINSON read a paper entitled "Remarks upon the nature and treatment of diphtheria with demonstrations."

At both these meetings there was a large attendance and the papers were received with much interest.

The third meeting was devoted to a conversazione. Between forty and fifty members were present, and many objects of much interest were exhibited. Among others may be mentioned the exhibits of Mr. McGarvie Smith, Prof. Stuart, Dr. W. C. Wilkinson, Dr. P. Sydney Jones, Dr. Norton Manning, and Dr. Eric Sinclair.

Mr. MCGARVIE SMITH showed the complete apparatus used in the prosecution of bacteriological research, demonstrated the methods of culture and the uses of the various instruments and incubators, and showed a large number of very interesting and valuable specimens of cultures, including growths of tubercle bacillus.

Plates, prints, and medical books of historical interest were shown by Drs. HOUSON, NORTON MANNING, and EICHLER.

Pathological and histological specimens were shown by Prof. STUART, Drs. JAMIESON, RENNIE and WILKINSON and E. SINCLAIR.

At the last meeting in December, Dr. HOUSON read a paper entitled, "Glimpses of the Past : a series of sketches with Pen and Pencil of the Medical History of Sydney."

The paper was illustrated with views of old hospital buildings, the portraits of medical men practising in the early days of the Colony and by the exhibition of old books, papers, &c., bearing upon the subject. About thirty-five members were present and Dr. Houson was cordially thanked for the highly interesting nature of his communication, the materials for which it must have been a difficult matter to so successfully collect and arrange.

MICROSCOPICAL SECTION.

A preliminary meeting of this section was held on 22nd April, 1891, Mr. S. MACDONNELL being in the chair. The following officers were elected for the year :—Mr. H. O. WALKER, Chairman.

Mr. S. MACDONNELL, Secretary. Committee: Dr. H. G. A. WRIGHT, Dr. L. R. HUXTABLE, Messrs. F. B. KYNGDON, P. N. TREBECK, G. D. HIRST, T. F. WIESENER.

Monthly meeting, 11th May, 1891.

Mr. H. O. WALKER in the Chair.

Mr. H. O. WALKER exhibited a hydra and fresh-water gathering of infusoria from Parramatta River.

Monthly meeting 13th July, 1891.

Dr. WRIGHT in the Chair.

Several half inch objectives were tested and it was determined to purchase one by Wray of London for the Society.

Monthly meeting 10th August, 1891.

Mr. H. O. WALKER in the Chair.

The Rev. J, MILNE CURRAN explained his "Notes on Slicing Rocks for Microscopical Study," and exhibited rock sections in various stages of preparation for mounting, also Dick and Swift's new petrological microscope and a large number of complete mounts of rock sections.

Mr. J. MCGARVIE SMITH exhibited anthrax bacillus in the spleen of the guinea pig, typhoid bacillus in human spleen and pure cultivations of the same organism, also pure cultivations of *bacillus tuberculosis* and sputum from a sufferer showing the bacillus.

Mr. MINGAYE exhibited a specimen of emeralds in matrix from Emmaville, New South Wales.

Monthly meeting 14th September, 1891.

Mr. F. B. KYNGDON in the Chair.

Mr. KYNGDON exhibited Reichert's modification of Abbe's camera lucida and called attention to the merits of Reichert's students' microscopes.

Monthly meeting 12th October, 1891.

Mr. P. R. PEDLEY in the Chair.

Dr. WRIGHT exhibited for Dr. Morris, Baker's latest adaptation

of Nelson's improved microscope with the Abbe substage illuminator.

Dr. WRIGHT exhibited an apochromatic dry $\frac{1}{4}$ inch objective and apochromatic condenser, both by Powell and Lealand, and photographs of *Pleurosigma angulatum*.

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1891.

(The Names of the Donors are in *Italics*.)

TRANSACTIONS, JOURNALS, REPORTS, &c.

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F. W. WHITE, TYP.

EXCHANGES AND PRESENTATIONS

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- | | | | |
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| 2 | LA PLATA ... | ...* | Directeur Général de Statistique de la Province de Buénos Ayres. |
| 3 | „ ... | ...* | Museo de La Plata. Provincia de Buenos Aires. |

Austria.

- | | | | |
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- | | | | |
|----|----------------|------|--|
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| 20 | „ ... | ...* | Société Royale des Sciences de Liège. |
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EXCHANGES AND PRESENTATIONS.

Brazil.

- 23 RIO DE JANEIRO ...*Observatoire Impérial de Rio de Janeiro.

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- 24 SANTIAGO ...*Sociedad Cientifica Alemana.

Denmark.

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 SUR-MER (Alp. } Laboratoire de Zoologie.
 Mar.) ... }

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Germany.

- | | | | |
|----|-------------------|-----|--|
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| 73 | „ | ... | ...*Statistische Bureau des Ministeriums des Innern zu Dresden. |
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| 84 | „ | ... | ...*Deutsche Seewarte. |
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| 86 | „ | ... | ...*Naturhistorisches Museum. |
| 87 | „ | ... | ...*Verein für Naturwissenschaftliche Unterhaltung in Hamburg. |
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EXCHANGES AND PRESENTATIONS.

- 100 STUTTGART ...*Verein für Vaterländische Naturkunde in
Württemberg.

Great Britain and the Colonies.

- 101 BIRMINGHAM ...*Birmingham and Midland Institute.
102 " ...*Birmingham Philosophical Society.
103 BRISTOL ...*Bristol Naturalists' Society.
104 CAMBORNE ...*Mining Association and Institute of Cornwall.
105 CAMBRIDGE ...*Philosophical Society.
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107 " ... Union Society.
108 " ... University Library.
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111 " ...*Leeds Philosophical and Literary Society.
112 " ...*Yorkshire College.
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123 " ...*Institution of Naval Architects.
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127 " ... London Institution.
128 " ...*Lords Commissioners of the Admiralty.
129 " ...*Lord Lindsay's Observatory.
130 " ...*Meteorological Office.
131 " ...*Mineralogical Society.
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143 " ...*Royal Historical Society.
144 " ...*Royal Institution of Great Britain.
145 " ...*Royal Meteorological Society.
146 " ...*Royal Microscopical Society.
147 " ... Royal School of Mines.
148 " ...*Royal Society.
149 " ... Royal Society of Literature.
150 " ...*Royal United Service Institution.

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- 151 LONDON*Sanitary Institute of Great Britain.
 152 " Society of Arts.
 153 " University of London.
 154 " War Office—(Intelligence Division).
 155 "*Zoological Society.
 156 MANCHESTER*Geological Society.
 157 "*Literary and Philosophical Society.
 158 " Owens College.
 159 NEWCASTLE-UPON- } *Natural History Society of Northumberland
 TYNE... ... } Durham and Newcastle-upon-Tyne.
 160 "*North of England Institute of Mining and
 Mechanical Engineers.
 161 " Society of Chemical Industry.
 162 OXFORD*Ashmolean Library.
 163 "*Bodleian Library.
 164 "*Radcliffe Library.
 165 "*Radcliffe Observatory.
 166 PENZANCE... ...*Royal Geological Society of Cornwall.
 167 PLYMOUTH*Plymouth Institution and Devon and Cornwall
 Natural History Society.
 168 WINDSOR The Queen's Library.

CAPE OF GOOD HOPE.

- 169 CAPE TOWN*South-African Philosophical Society.

CEYLON.

- 170 COLOMBO*Royal Asiatic Society (Ceylon Branch.)

DOMINION OF CANADA.

- 171 HALIFAX (Nova } *Nova Scotian Institute of Natural Science.
 Scotia) }
 172 HAMILTON (Ont.) *Hamilton Association.
 173 MONTREAL*Natural History Society of Montreal.
 174 "*Royal Society of Canada.
 175 OTTAWA*Geological and Natural History Survey of Canada.
 176 " Ottawa Literary and Scientific Society.
 177 TORONTO*Canadian Institute.
 178 " University.
 179 WINNIPEG*Manitoba Historical and Scientific Society.

INDIA.

- 180 CALCUTTA... ...*Asiatic Society of Bengal.
 181 "*Geological Survey of India.

IRELAND.

- 182 DUBLIN*Royal Dublin Society.
 183 "*Royal Geological Society of Ireland.
 184 "*Royal Irish Academy.

MAURITIUS.

- 185 PORT LOUIS Royal Society of Arts and Sciences.
 186 " Société d'Acclimatation de l' Ile Maurice.

NEW SOUTH WALES.

- 187 SYDNEY*Australian Museum.
 188 "*Department of Agriculture.
 189 "*Engineering Association of New South Wales.
 190 "*Free Public Library.
 191 "*Linnean Society of New South Wales.

EXCHANGES AND PRESENTATIONS.

192	SYDNEY	...	...*Mining Department.
193	"	...	...*Observatory.
194	"	...	... New South Wales Government Railways Institute.
195	"	...	... Public Works Department.
196	"	...	... School of Arts.
197	"	...	...*Technological Museum.
198	"	...	...*United Service Institution of New South Wales.
199	"	...	...*University.

NEW ZEALAND.

200	AUCKLAND	...	...*Auckland Institute.
201	CHRISTCHURCH	...	... Philosophical Institute of Canterbury.
202	DUNEDIN	...	... Otago Institute.
203	WELLINGTON	...	...*Colonial Museum.
204	"	...	...*New Zealand Institute.

QUEENSLAND.

205	BRISBANE	...	...*Acclimatization Society of Queensland.
206	"	...	...*Royal Geographical Society of Australasia (Queensland Branch).
207	"	...	... Parliamentary Library.
208	"	...	...*Royal Society of Queensland.

SCOTLAND.

209	ABERDEEN	...	...*University.
210	EDINBURGH	...	...*Editor, <i>Encyclopædia Britannica</i> , (Messrs. A. and C. Black.)
211	"	...	...*Edinburgh Geological Society.
212	"	...	...*Highland and Agricultural Society of Scotland.
213	"	...	...*Royal Botanic Garden.
214	"	...	...*Royal Observatory.
215	"	...	...*Royal Physical Society.
216	"	...	...*Royal Scottish Geographical Society.
217	"	...	...*Royal Society.
218	"	...	...*University.
219	GLASGOW	...	...*Geological Society of Glasgow.
220	"	...	...*Philosophical Society.
221	"	...	...*University.

SOUTH AUSTRALIA.

222	ADELAIDE	...	...*Government Botanist.
223	"	...	...*Government Printer.
224	"	...	...*Observatory.
225	"	...	...*Royal Society of South Australia.
226	"	...	...*Public Library, Museum, and Art Gallery of South Australia.
227	"	...	...*University.

STRAITS SETTLEMENTS.

228	SINGAPORE*Royal Asiatic Society (Straits Branch).
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TASMANIA.

229	HOBART*Royal Society of Tasmania.
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VICTORIA.

230	BALLAARAT*School of Mines and Industries.
231	MARYBOROUGH District School of Mines, Industries and Science.
232	MELBOURNE	...	...*Field Naturalists' Club of Victoria.
233	"	...	...*Government Botanist.

EXCHANGES AND PRESENTATIONS.

234	MELBOURNE	...*Government Statist.
235	"	...*Mining Department.
236	"	...*Observatory.
237	"	...*Public Library.
238	"	...*Registrar-General.
239	"	...*Royal Society of Victoria.
240	"	...*University.
241	"	...*Victorian Institute of Surveyors.
242	"	...*Working Men's College.
243	STAWELL ...	...*School of Mines, Art, Industry and Science.

Hayti.

244	PORT-AU-PRINCE...	Société de Sciences et de Géographie.
-----	-------------------	---------------------------------------

Hungary.

245	BISTRITZ (in Siebenbürgen) }	*Direction der Gewerbeschule.
246	TRENCSEN ...	... Naturwissenschaftliche Verein des Trencsiner Komitates.
247	ZAGREB (Agram)...	*Société Archéologique Croate.

Italy.

248	BOLOGNA ...	...*Accademia delle Scienze dell'Istituto di Bologna.
249	" ...	... Università di Bologna.
250	FLORENCE	...*Società Africana d' Italia (Sezione Fiorentina).
251	" ...	...*Società Entomologica Italiana.
252	" ...	...*Società Italiana di Antropologia e di Etnologia.
253	GENOA ...	...*Museo Civico di Storia Naturale.
254	MILAN ...	... Reale Istituto Lombardo di Scienze Lettere ed Arti.
255	" ...	...*Società Italiana di Scienze Naturali.
256	MODENA ...	...*R. Accademia di Scienze, Lettere ed Arti.
257	NAPLES ...	...*Società Africana d' Italia.
258	" ...	...*Società Reale di Napoli (Accademia delle Scienze Fisiche e Matematiche).
259	" ...	...*Stazione Zoologica (Dr. Dohrn).
260	PALERMO ...	...*Accademia Palermitana di Scienze Lettere ed Arti.
261	" ...	... Reale Istituto Tecnico.
262	PISA ...	...*Società Toscana di Scienze Naturali.
263	ROME*Accademia Pontificia de 'Nuovi Lincei.
264	"*Biblioteca e Archivio Tecnico (Ministero dei Lavori Pubblico).
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267	"*R. Accademia dei Lincei.
268	"*R. Comitato Geologico Italiano.
269	"*Società Geografica Italiana.
270	SIENA ...	...*R. Accademia dei Fisiocritici in Siena.
271	TURIN ...	... Reale Accademia della Scienze.
272	" ...	... Regio Osservatorio della Regia Università.
273	VENICE ...	...*Reale Istituto Veneto di Scienze, Lettere ed Arti.

Japan.

274	TOKIO ...	...*Imperial University.
275	" ...	...*Seismological Society of Japan.
276	YOKOHAMA	...*Asiatic Society of Japan.

EXCHANGES AND PRESENTATIONS.

Java.

- 277 BATAVIA ... *Kon. Natuurkundige Vereeniging in Nederl Indië.

Mexico.

- 278 MEXICO ... *Sociedad Cientifica "Antonio Alzate."

Netherlands.

- 279 AMSTERDAM ... *Académie Royale des Sciences.
280 " ... *Société Royale de Zoologie.
281 HARLEM ... *Bibliothèque de Musée Teyler.
282 " ... *Société Hollandaise des Sciences.

Norway.

- 283 BERGEN ... *Museum.
284 CHRISTIANIA ... *Kongelige Norske Fredericks Universitet.
285 " ... *Videnskabs-Selskabet i Christiania.
286 TROMSO ... *Museum.

Roumania.

- 287 BUCHAREST ... *Institutul Meteorologic al Romăniei.

Russia.

- 288 HELSINGFORS ... *Société des Sciences de Finlande.
289 KIEFF ... *Société des Naturalistes.
290 MOSCOW ... *Société Impériale des Naturalistes.
291 " ... *Société Impériale des Amis des Sciences Naturelles d' Anthropologie et d' Ethnographie à Moscow (Section d' Anthropologie).
292 ST. PETERSBURG... *Académie Impériale des Sciences.
293 " ... *Comité Géologique—Institut des Mines.

Spain.

- 294 MADRID ... Instituto geografico y Estadístico.

Sweden.

- 295 STOCKHOLM ... *Kongliga Svenska Vetenskaps-Akademien.
296 " ... *Kongliga Universitetet.

Switzerland.

- 297 BERNE ... *Société de Géographie de Berne.
298 GENEVA ... *Institut National Genèveis.
299 LAUSANNE ... *Société Vaudoise des Sciences Naturelles.
300 NEUCHATEL ... *Société des Sciences Naturelles de Neuchatel.

United States of America.

- 301 ALBANY ... *New York State Library, Albany.
302 ANNAPOLIS (MD.) *Naval Academy.
303 BALTIMORE ... *Johns Hopkins University.
304 BELOIT (Wis.) ... *Chief Geologist.
305 BOSTON ... *American Academy of Arts and Sciences.
306 " ... *Boston Society of Natural History.
307 " ... State Library of Massachusetts.
308 BROOKVILLE (Ind.) *Brookville Society of Natural History.
309 " ... Indiana Academy of Science.

EXCHANGES AND PRESENTATIONS.

- 310 BUFFALO (Ind.) ...*Buffalo Society of Natural Sciences.
- 311 CAMBRIDGE (Mass.) *Cambridge Entomological Club.
- 312 " ...*Museum of Comparative Zoology at Harvard College.
- 313 CHICAGO Academy of Sciences.
- 314 CINCINNATI ...*Cincinnati Society of Natural History.
- 315 COLDWATER ... Michigan Library Association.
- 316 DAVENPORT (Iowa) *Academy of Natural Sciences.
- 317 DENVER*Colorado Scientific Society.
- 318 HOBOKEN (N.J.) ...*Steven's Institute of Technology.
- 319 IOWA CITY (Iowa) *Director Iowa Weather Service.
- 320 JEFFERSON CITY...*Geological Survey of Missouri.
- 321 MINNEAPOLIS ...*Minnesota Academy of Natural Sciences.
- 322 NEWHAVEN (Conn) *Connecticut Academy of Arts and Sciences.
- 323 NEW YORK ...*American Chemical Society.
- 324 " ...*American Geographical Society.
- 325 " ... American Museum of Natural History.
- 326 " ...*Editor *Journal of Comparative Medicine and Veterinary Archives.*
- 327 " ... Editor *Science.*
- 328 " ...*New York Academy of Sciences.
- 329 " ...*New York Microscopical Society.
- 330 " ...*School of Mines, Columbia College.
- 331 PHILADELPHIA ...*Academy of Natural Science.
- 332 " ...*American Entomological Society.
- 333 " ...*American Philosophical Society.
- 334 " ...*Franklin Institute.
- 335 " ...*Geological Survey of Pennsylvania.
- 336 " ...*Wagner Free Institute of Science.
- 337 " ...*Zoological Society of Philadelphia.
- 338 SALEM (Mass.) ...*American Association for the Advancement of Science.
- 339 " ...*Essex Institute.
- 340 " ...*Peabody Academy of Sciences.
- 341 ST. LOUIS*Academy of Science.
- 342 SAN FRANCISCO ...*California Academy of Sciences.
- 343 " ...*California State Mining Bureau.
- 344 WASHINGTON ... American Medical Association.
- 345 " ...*Bureau of Education (Department of the Interior).
- 346 " ...*Bureau of Ethnology.
- 347 " ...*Chief of Engineers (War Department).
- 348 " ...*Chief of Ordnance (War Department).
- 349 " ...*Chief Signal Officer (War Department).
- 350 " ...*Department of Agriculture.
- 351 " ...*Director of the Mint (Treasury Department).
- 352 " ... Library (Navy Department).
- 353 " ...*National Academy of Sciences.
- 354 " ...*Office of Indian Affairs (Department of the Interior).
- 355 " ...*Philosophical Society.
- 356 " ...*Secretary (Department of the Interior).
- 357 " ...*Secretary (Treasury Department).
- 358 " ...*Smithsonian Institution.
- 359 " ...*Surgeon General (U.S. Army).
- 360 " ...*U. S. Coast and Geodetic Survey (Treasury Department).

EXCHANGES AND PRESENTATIONS.

361	WASHINGTON	...*U.S. Geological Survey.
362	„	...*U. S. National Museum (Department of the Interior).
363	„	... U.S. Patent Office.
364	„	...*War Department.

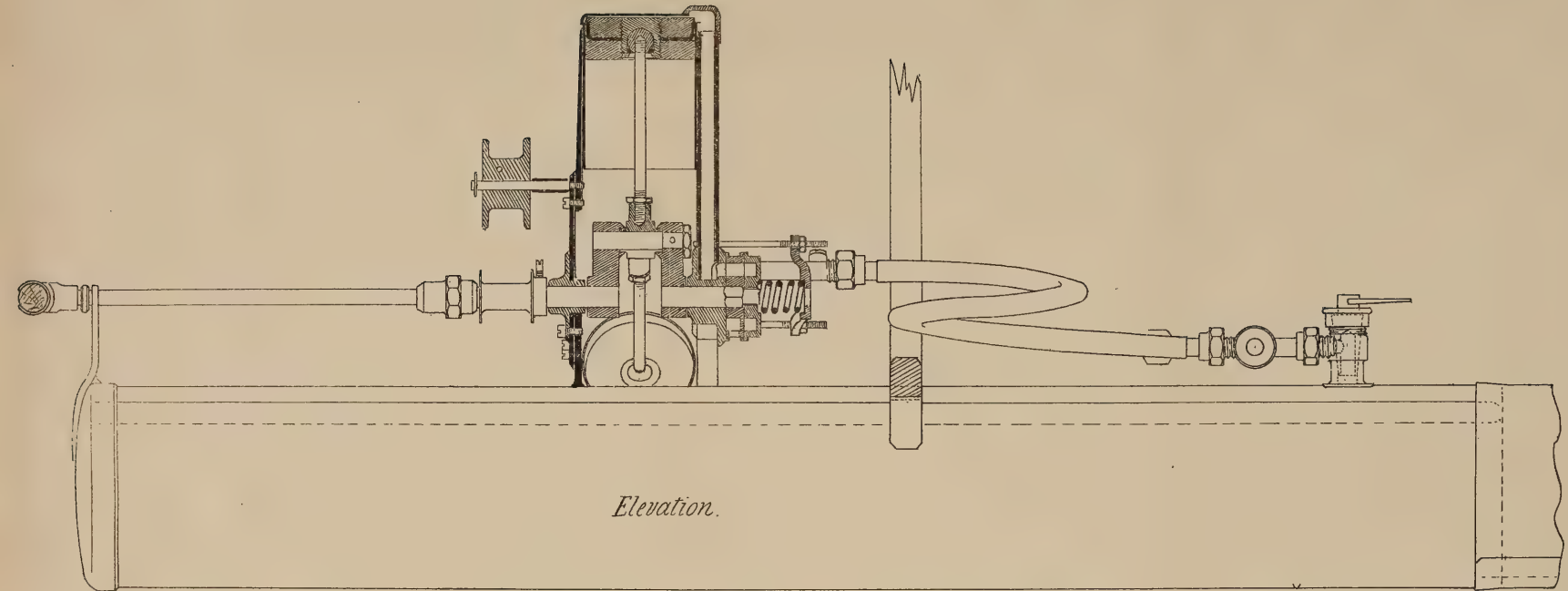
Number of Publications sent to Great Britain		...	...	83
„	„	India and the Colonies	...	59
„	„	America	... ..	66
„	„	Europe	... ..	147
„	„	Asia, &c.	... ..	5
„	„	Editors of Periodicals	...	4

Total 364

F. B. KYNGDON... }
W. H. WARREN... } Hon. Secretaries.

The Society's House, Sydney, 13th April, 1891.

Diagram I.



Elevation.

Scale

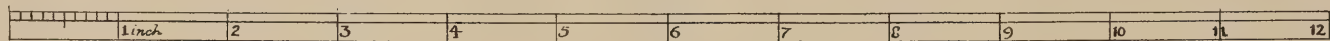


Diagram II.

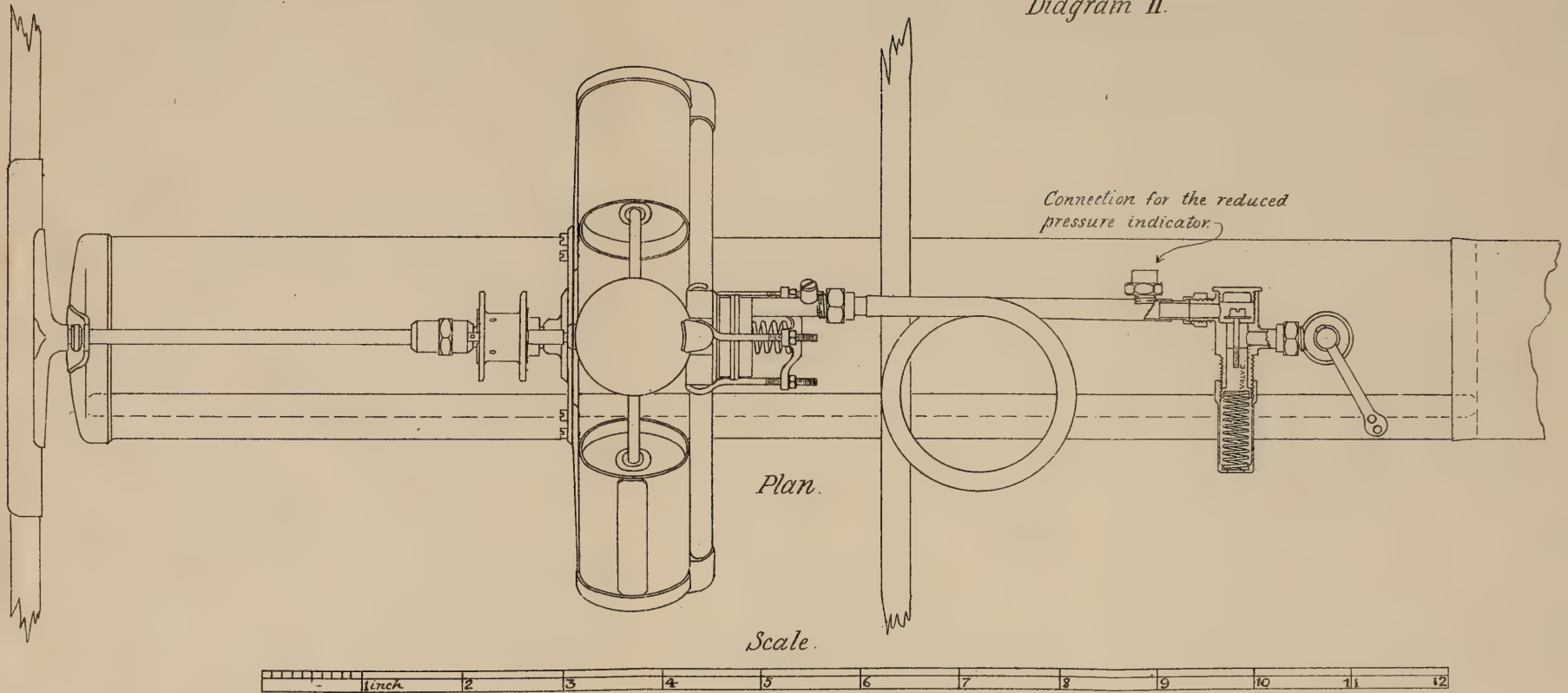
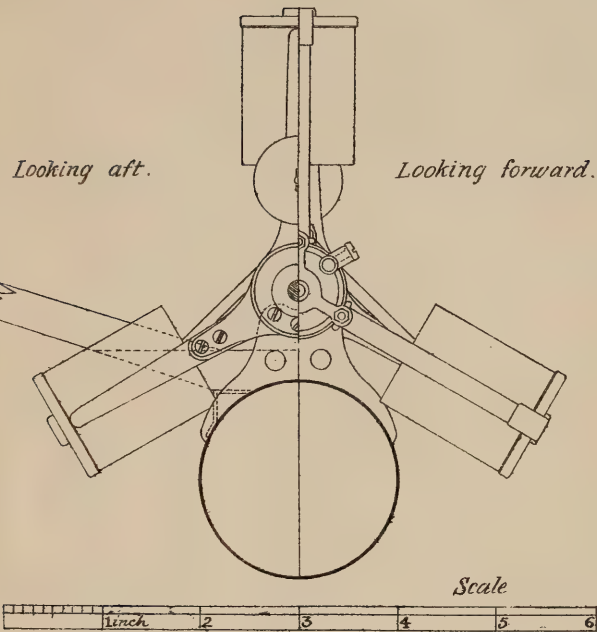


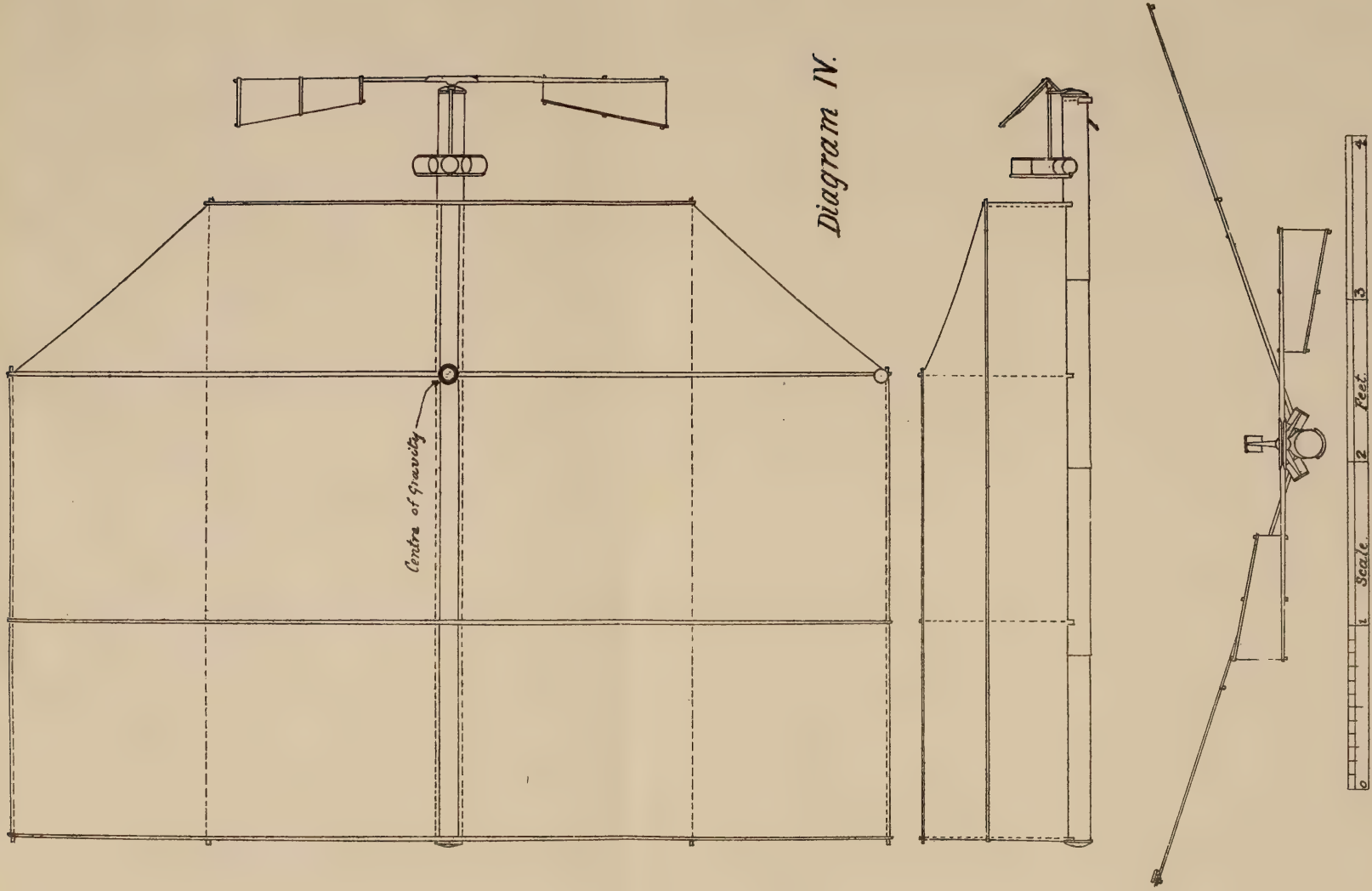
Diagram III.



No. 13.

Diameter of the cylinders.	1.125 ins.	Weight of engine, receiver & screw	34 oz.
Stroke	1.126 ins	Weight of body-plane	8 oz.
Valve cuts off air at	.8 of stroke.	Balance weight under the bow	2 oz.
Revolutions: at the rate of	367 per min.	Listing weight	1 oz.
Receiver pressure {initial}	230 lbs.	Charge of air	1.86 oz.
Reduced pressure	45 lbs.	Total weight	46.86 oz.
Diameter of the screw	31.6 ins.	Distance flown	128 feet.
Pitch	8 ft. 4 ins.	Time of flight	8 seconds
Pitch angle	45°	Revolutions of engine	49.
Area of the two blades	70 sq. ins.	Speed.	10.34 miles per hour.
Projected area of one blade	25 sq. in	Work done	143 foot-pounds.
Area of the body plane	2927 sq. ins	Length of the receiver	4 ft. 7½ in.
Total area 20.5 Sq.ft =	2952 sq. ins	Content	.0936 cub. ft. = 161.9 cub. ins.
Area per lb. weight	1029 sq. ins	Test pressure	410 lbs. per sq. in.
Area before the centre of gravity	22.3 %		

Diagram IV.



No. 13. Compressed-air Flying-machine.

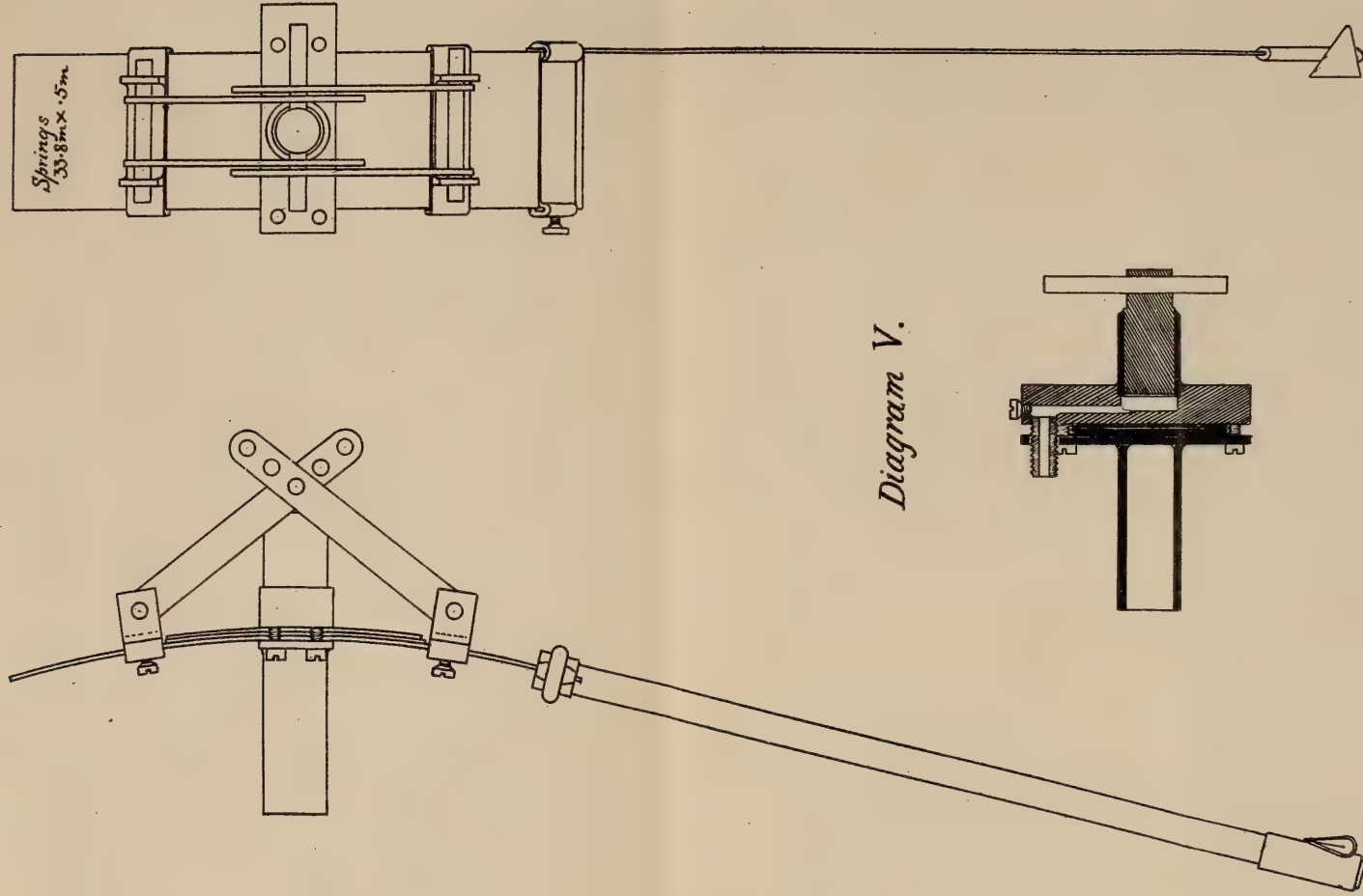
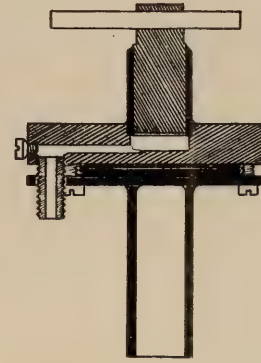
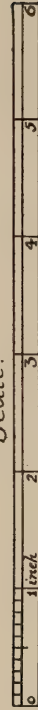


Diagram V.



Scale.



Indicator.

Diagram VI.



Valve cylinder ports 0.9 x 1.5'

← Bollards for wing stays.

13 ins

Breaking Stick.

Scale

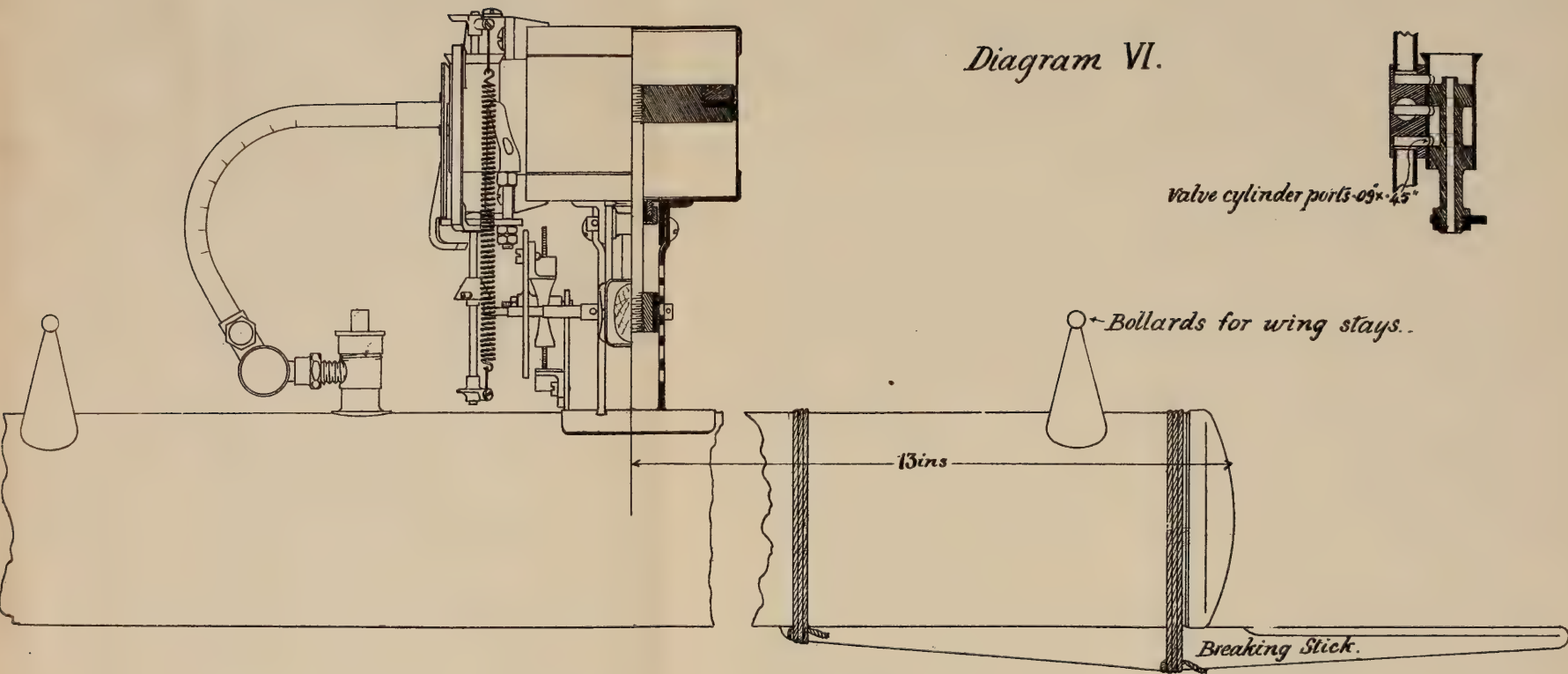
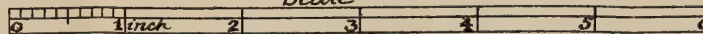
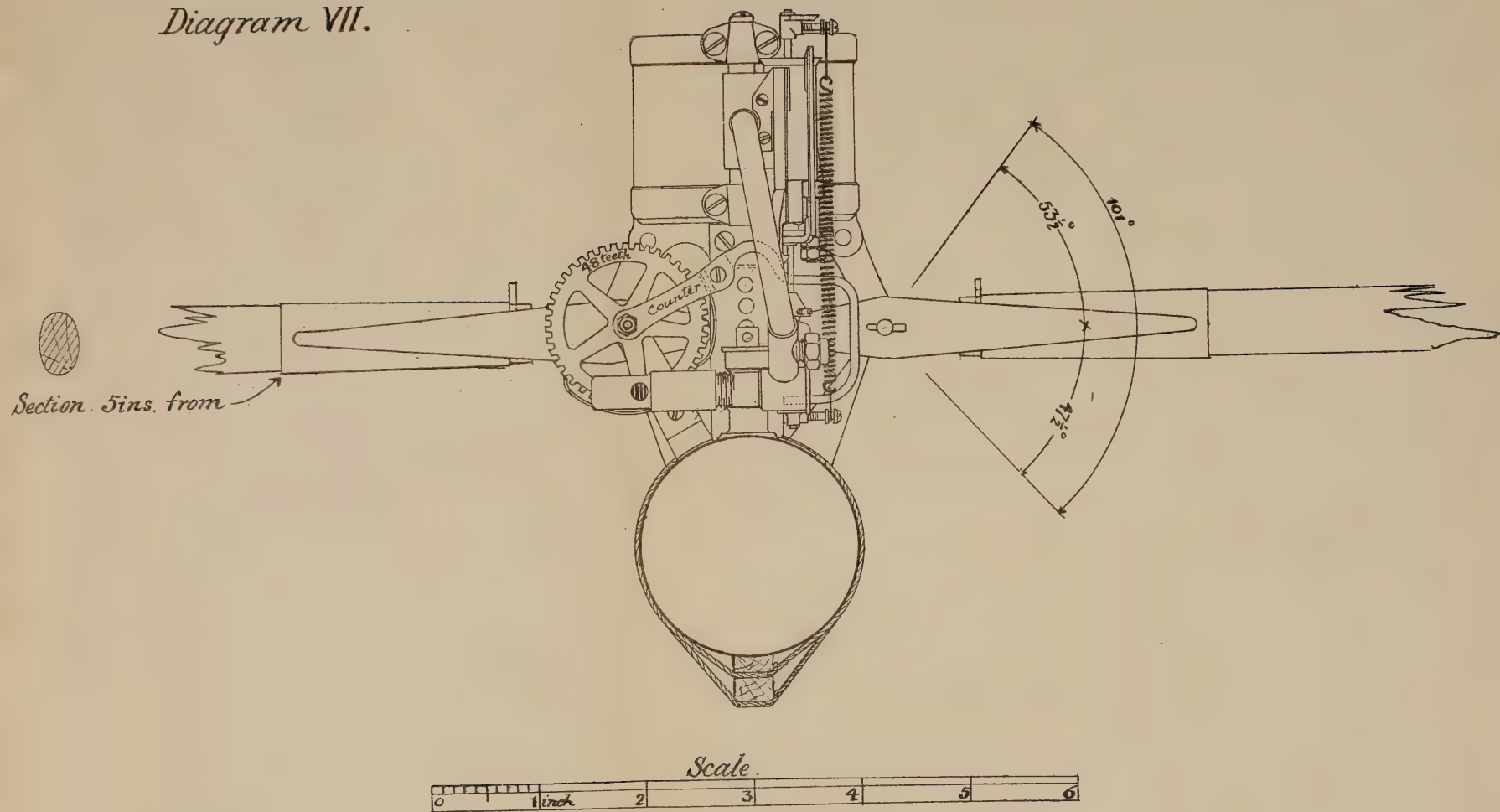




Diagram VII.





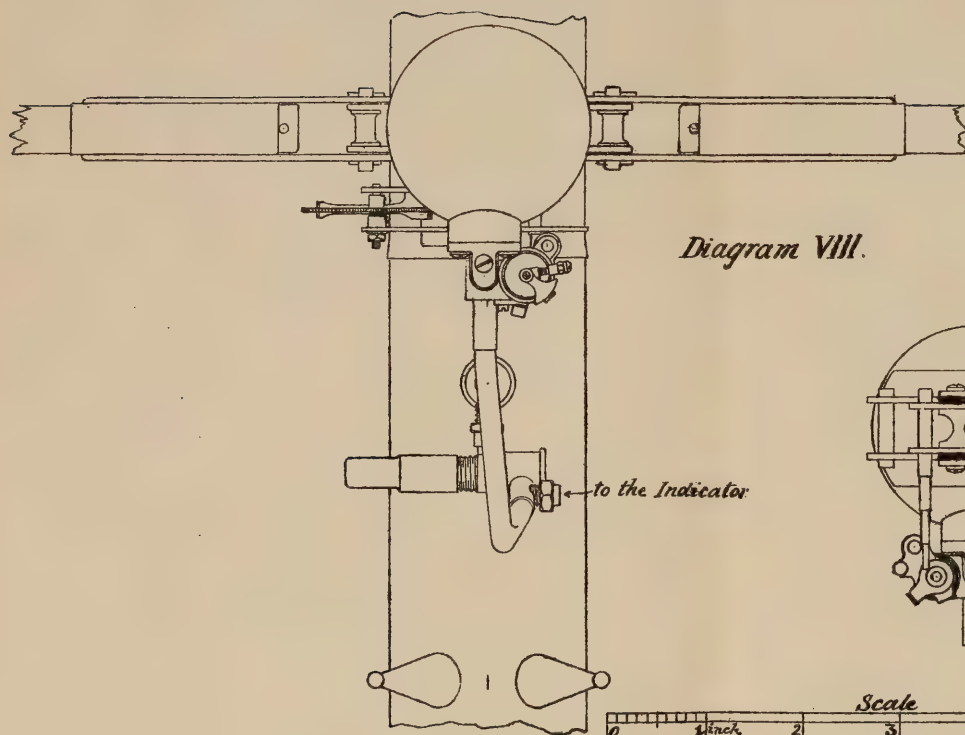


Diagram VIII.

No. 14.

Content of the receiver $145 \text{ cub. ft.} = 251 \text{ cub. ins.}$

Dimensions " " $6 \text{ ft } 11 \frac{1}{2} \text{ ins.} \times 2 \text{ ins.}$

Weight " " $32 \frac{1}{2} \text{ oz.}$

Thickness of shell & ends $.0126 \text{ ins.} = .32 \text{ m.}$

Test pressure $400 \text{ lbs. per sq. inch}$

Working pressure 250 " " "

Reduced pressure 57 " " "

Diameter of the cylinder 2 ins.

Stroke 1.28 ins.

Diameter of the valve $.449 \text{ ins.}$

Weight of the engine 11 oz.

" Body-plane & wings 11 oz.

" Air & cocks 4.5 oz.

Total weight, charged $3.69 \text{ lbs.} = 59 \text{ oz.}$

Length of the wings 31 ins. each

Area " " 216 sq. ins.

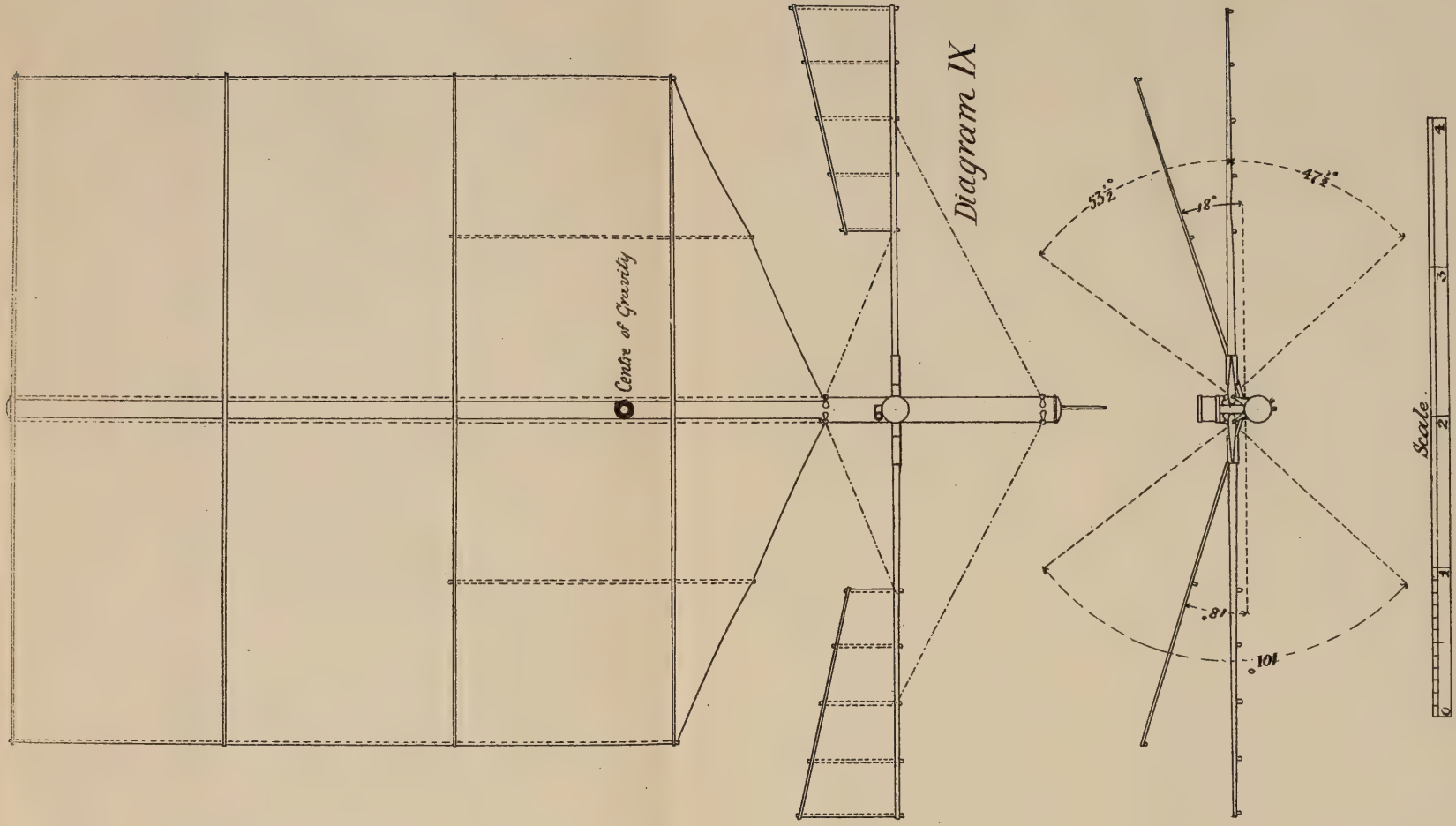
Area of the body plane 3074 sq. ins.

Total area $22.85 \text{ sq. ft.} = 3290 \text{ sq. ins.}$

Area in advance of the centre of Gravity 732 sq. ins.

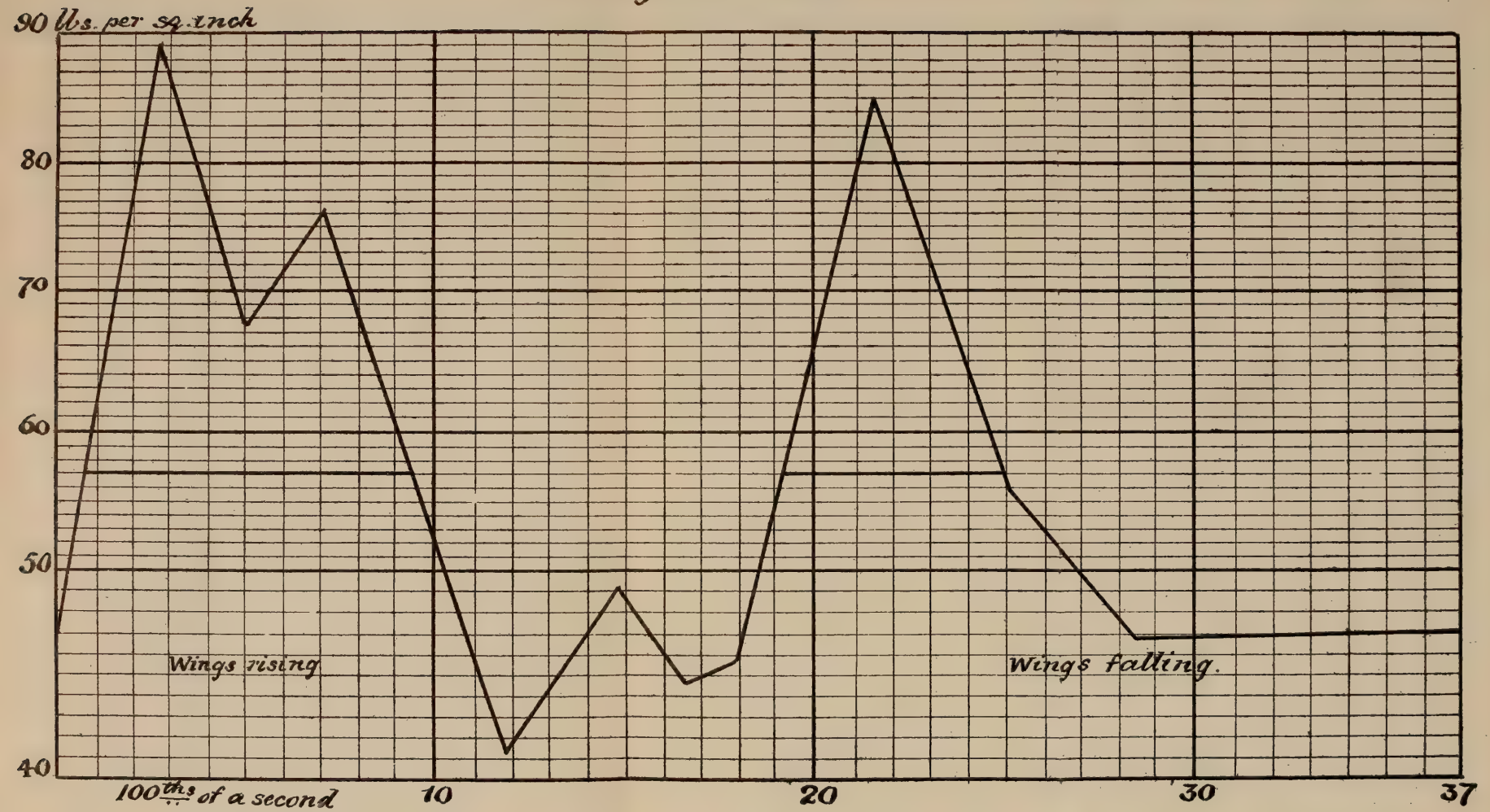
Centre of Gravity from centre of Engine $= 22.27\%$

Square ins. area per lb. weight $891.$



No 14. Compressed-air Flying-machine.

Diagram X.



Pressures in the air-pipe of No. 14. during one double vibration



KAPPA CRUCIS CLUSTER.

Scale $1'' = 10$ inches.

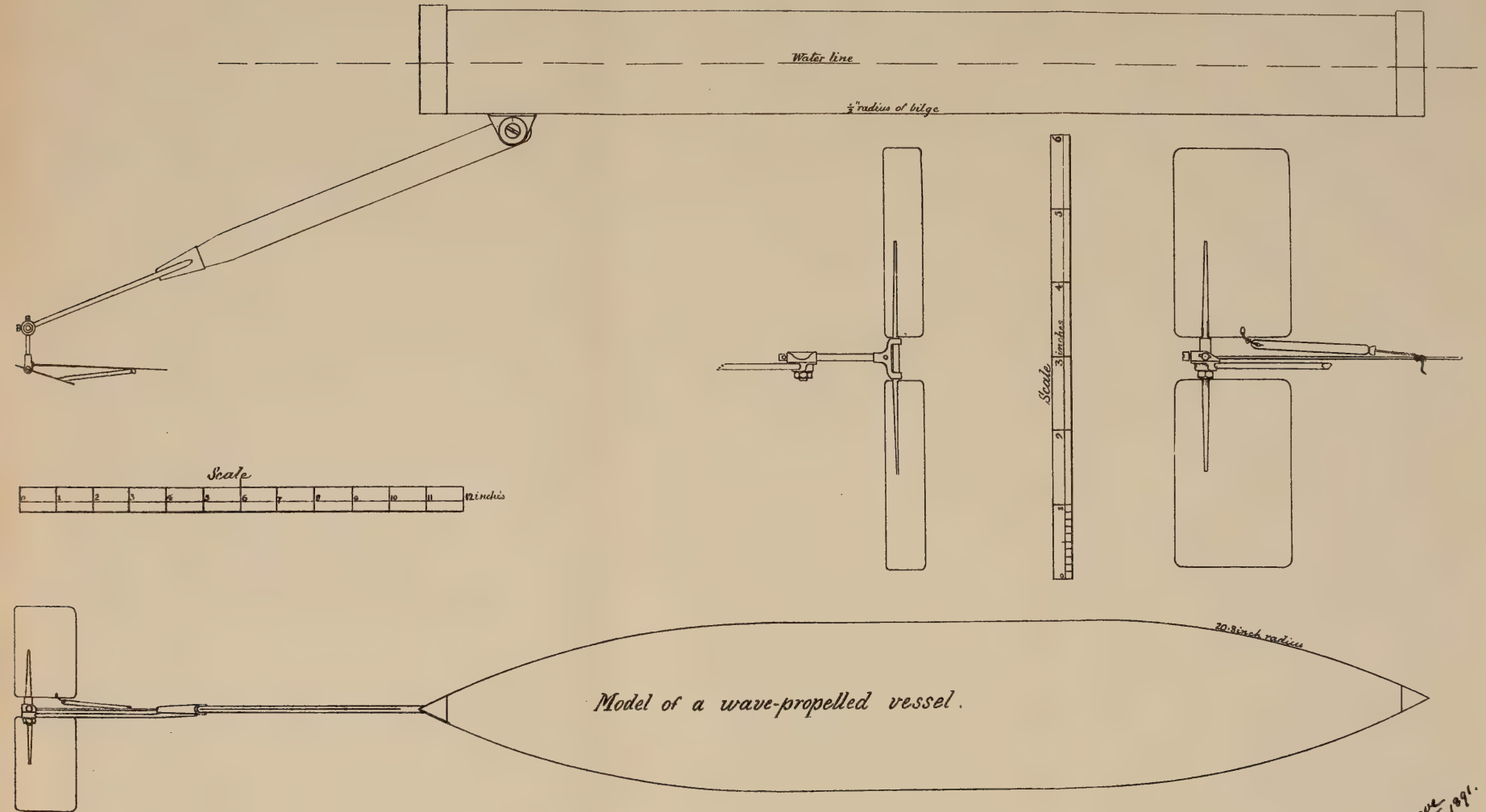


Diagram I.

Lawton & Co.
August 20th 1891.



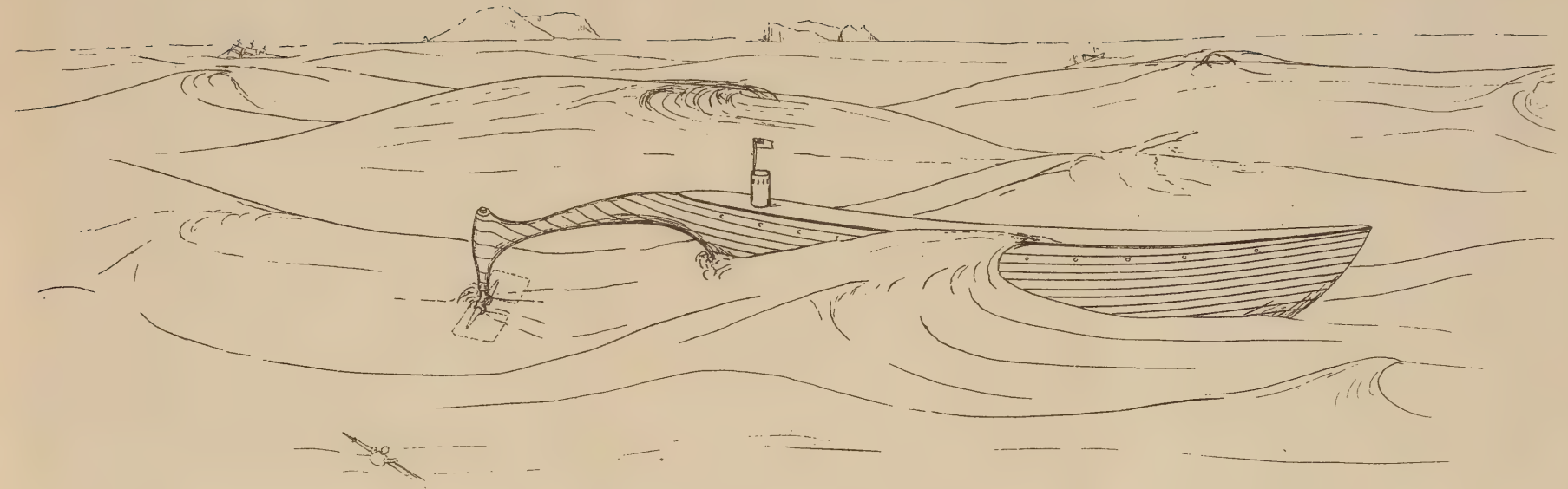


Diagram II.

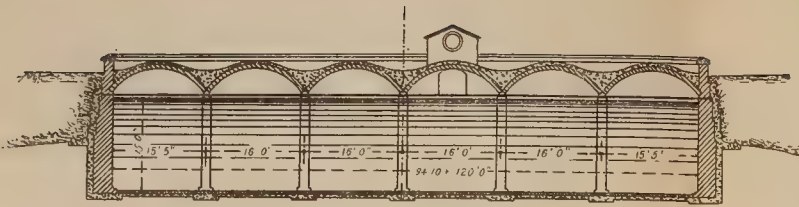
For L. Hargrave's Paper "On a Wave-propelled Vessel".

August 25th 1891.

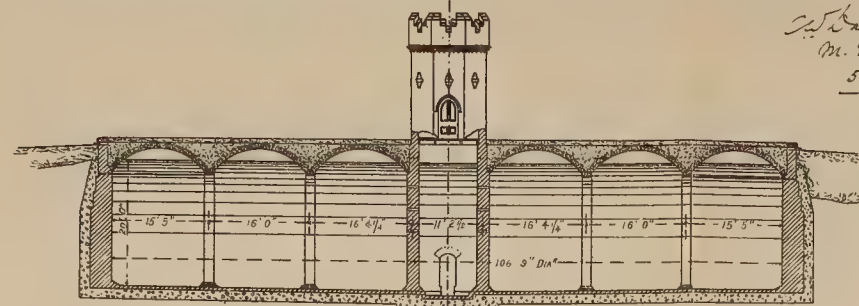
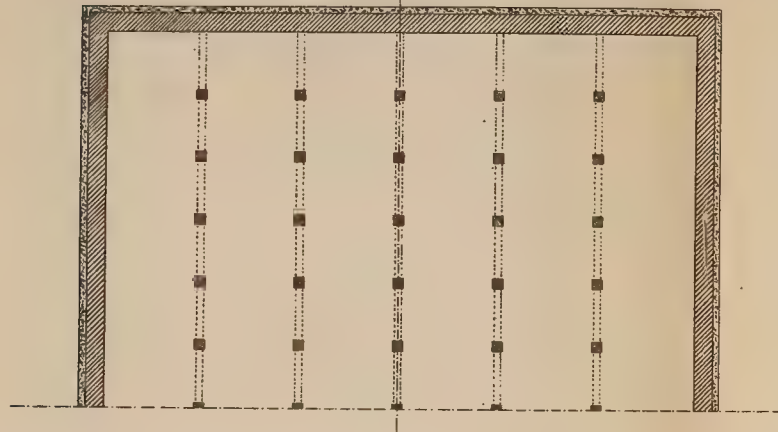
RESERVOIRS & TANKS

PLAN N^o I.

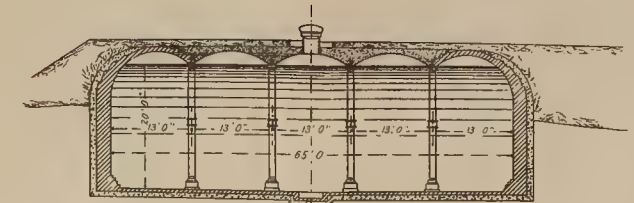
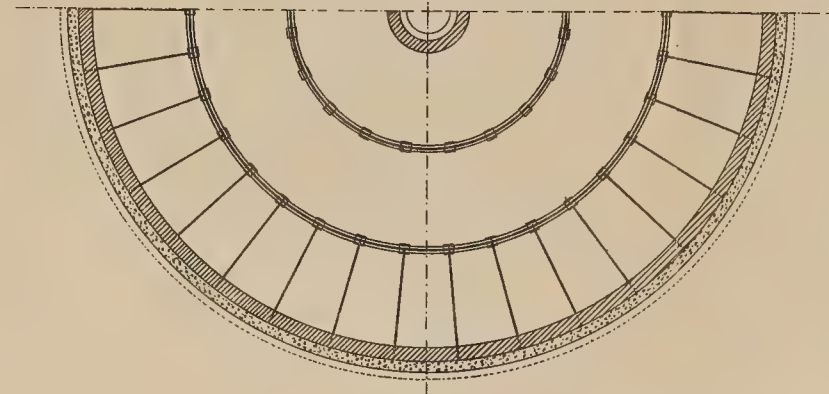
J. Darby
Mr. M. H. L.
5.10.91



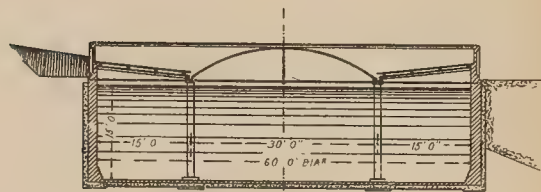
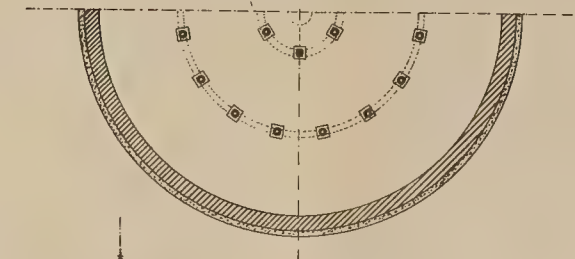
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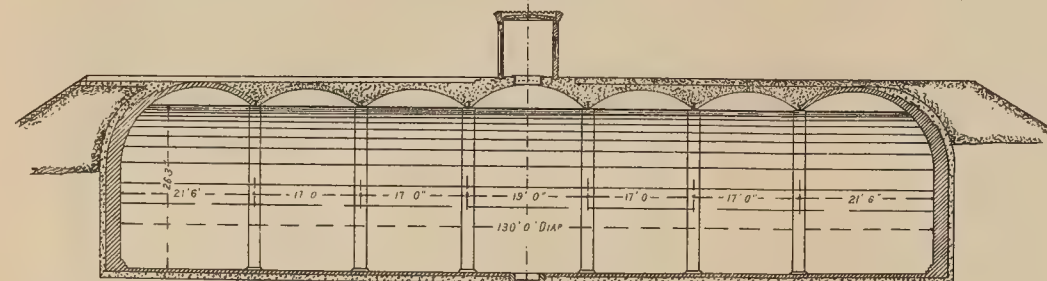
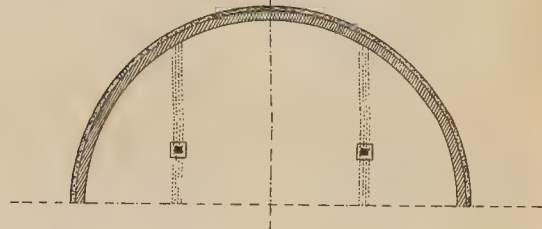
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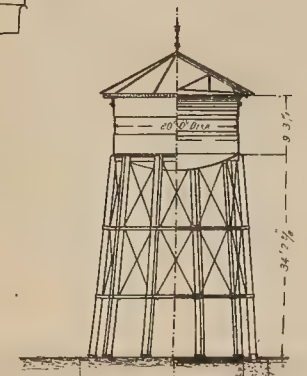
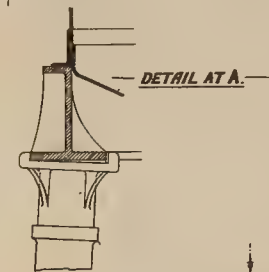
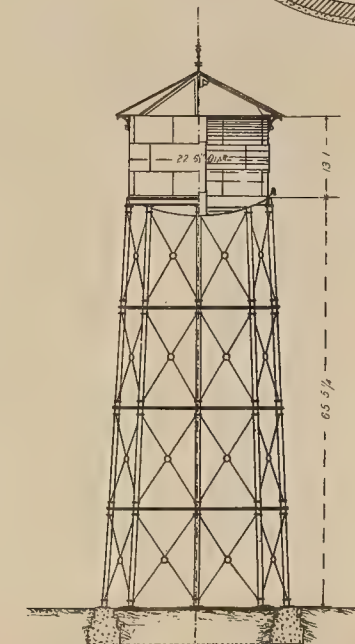
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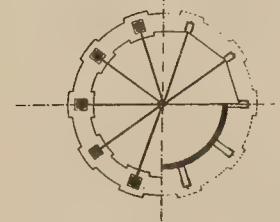
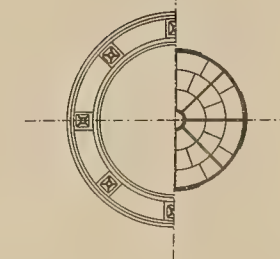
— TYPE D. —



— TYPE E. —



— TYPE E. —



TYPE. F.



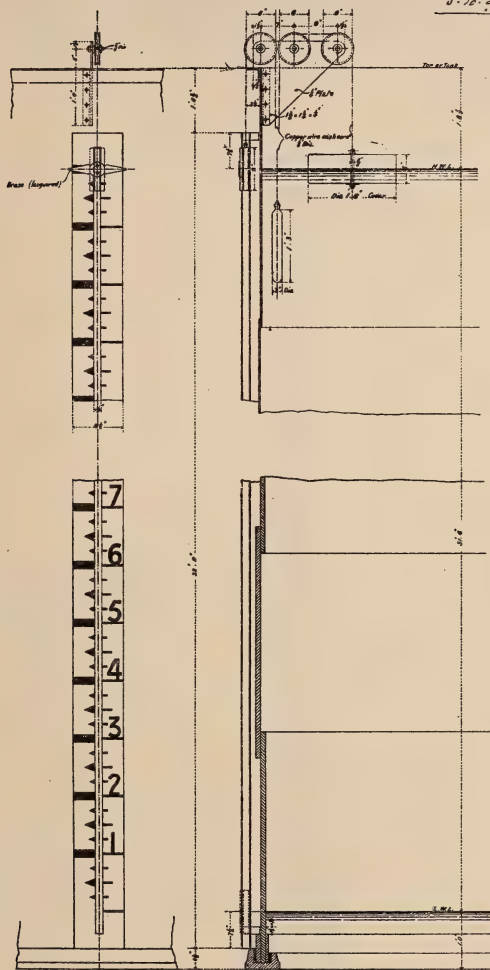
CHATSWOOD RESERVOIRS

PLAN N° 24

WATER LEVEL INDICATOR



C. D. Barber
M. Inst. C.
1870-71

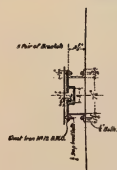


FRONT ELEVATION

SECTIONAL ELEVATION



PLAN



SECTIONAL PLAN

PLAN N^o 3.

SERVICE RESERVOIRS AT CHATSWOOD

EACH 100' DIAM² 32' 6" DEEP, CAPACITY 1½ M. GALLONS

DIAGRAM SHEWING THICKNESS OF PLATES

C. B. Bailey
m. m. f. d.
5.10.91

Steel Plates with a mean Strength of 28 Tons per sq. ins.
Horizontal Joints. single riveted lap.
Vertical joints double riveted butt double strips
with a strength = 80% of the solid Plate.

Factor of safety = 6.

Required thickness }
$$= \frac{100 \times 12 \times 14}{2240 \times 28 \times 2 \times .80} = .167 \text{ ins.}$$


at bottom

Actual thickness = .167 + 6 = 1' at bottom

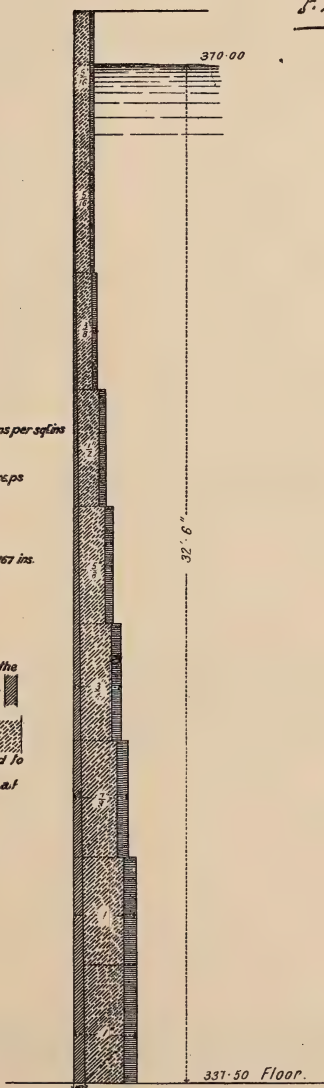
— Note —

Thickness of Plates required to resist the pressure of water is shewn thus —————

Excess of thickness provided for possible corrosion is shewn thus —————

Portions shewn thus  indicate 20% added to compensate for diminution of strength at vertical joints.

Pressure at bottom = 14 lbs per sq. inch

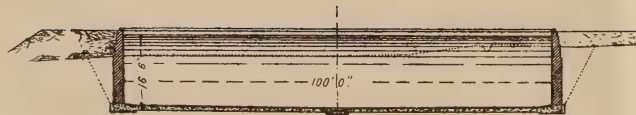
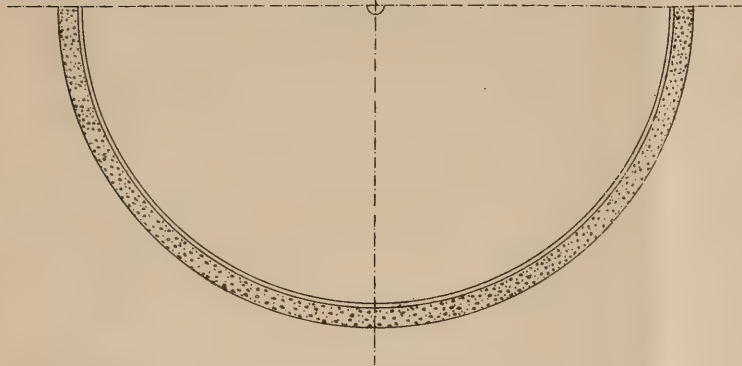


RESERVOIRS & TANKS

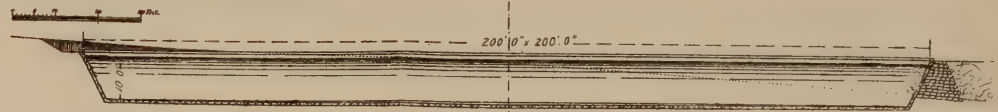
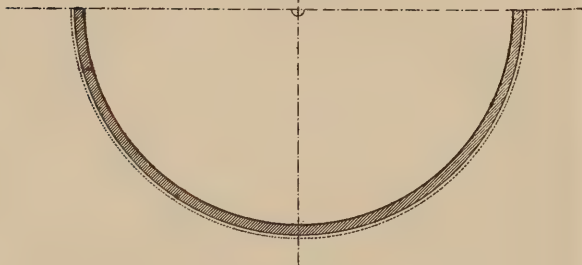
PLAN N° 4



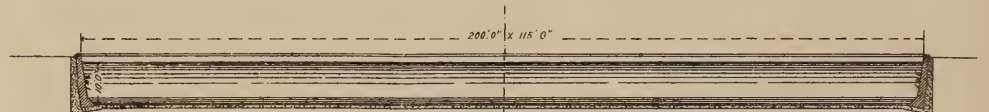
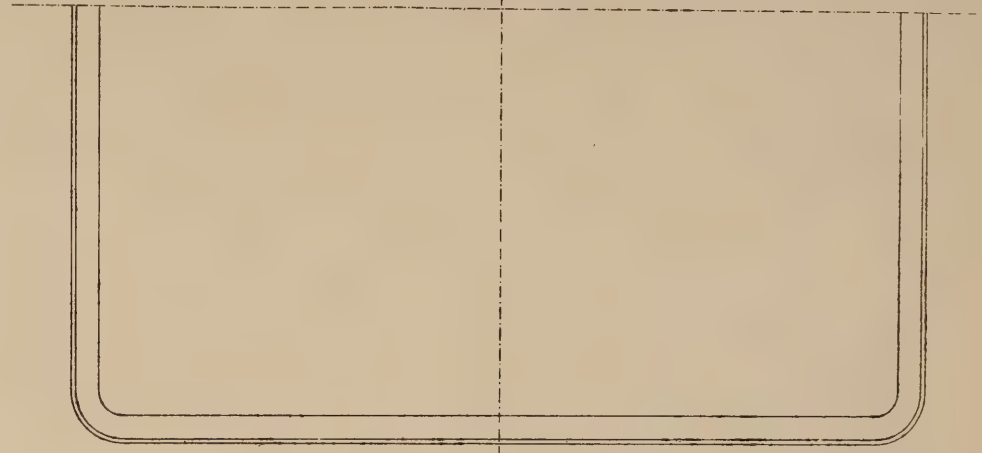
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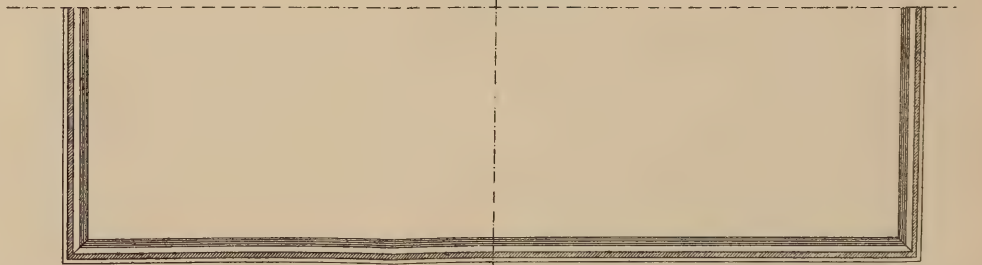
TYPE G.



TYPE H.



TYPE H.



C. J. Bailey
M. Inst. R.
5-10-91

SCHEDULE SHEWING

DIMENSIONS, CAPACITY, COST, & FORM OF CONSTRUCTION OF

RESERVOIRS

Ch Darling
M. 1861/66

5. 10. 71

Type of Reservoir— See Diagram	Service Reservoir or Settling Tank	Size, and Depth of Water	Covered or Open	Available Capacity in Gallons	Cost exclusive of Land	Cost per 1000 Gallons available Capacity	Nature of Ground	Construction
A	Service Reservoir	90' x 73' 10" x 12' Deep	Covered	501,500	£. 7,067	£ s d 14 1 9	Shale	Brick & Concrete Vertical Walls & floor, brick & Concrete covering, brick Piers, C.I. Girders.
A	do	72' 9 1/2" x 10' 1/2" x 16' do	do	1,030,000	9,569	9 5 9	Soft Sandstone	do do do do do do do do
A	do	110' x 100' x 18' do	do	1,000,000	12,000	12 0 0	Clay & Sand	Brick walls, better lining, backed with puddle, brick & concrete floor, on puddle, brick covering, carried by brick piers & arches.
B	do	100' Diam. 20' do	do	1,087,000	9,665	9 17 9	Sand	Brick & Concrete Vertical walls & floor, coke concrete covering, brick Piers, C.I. Girders
B	do	80' 6" do 15' do	do	484,000	3,319	7 3 7	Clay & Rock	do do do do do do do do
B	do	45' do 14' do	do	154,180	1,483	11 1 0	Conglomerate	do do do do do do do do
C	do	130' do 26' do	do	2,157,000	11,795	5 9 4	Shale	do Partly curved do do do do do do
C	do	80' do 15' do	do	383,000	3,202	8 7 2	Clay & Shale	do do do do do do C.I. columns & do
C	do	66' do 20' do	do	381,000	3,413	8 19 1	Clay & Rock	do do do do do do do do
C	do	66' do 20' do	do	381,000	3,420	8 19 6	Conglomerate & Bat	do do do do do do do do
D	do	60' do 12' do	do	198,200	1,952	9 16 11	Decomposed Granite	do Vertical do Corrugated Iron Roof, 1/2" wood Piers & do
D	do	30' do 12' do	do	49,600	882	17 16 4	do	do do do do do do do do
D	do	60' do 15' do	do	246,600	1,887	7 13 0	Clay & Shale	do do do do do do do do
D	do	60' do 18' do	do	246,600	2,104	8 10 7	Do & Rock	do do do do do do do do
E	do	22' 6" do 13' 6" do	do	32,900	1,905	57 18 0	Clay	Iron Tank, dished Bottom, elevated 64' on raking Cast Iron Columns.
E	do	22' 6" do 12' 10" do	do	31,350	1,491	47 11 1	Do	do do do 65' do Vertical do do
E	do	22' 6" do 12' 10" do	do	31,350	1,543	49 4 4	Do	do do do do do do do do
E	do	20' do 11' 6" do	do	20,000	966	48 5 0	Sandstone	do do do do do do 34' on raking Timber Supports
E'	do	36' do 18' do	Open	100,000	2,120	21 4 0	Clay	do do do 30' on brick cylinder, with arched openings
F	do	75' do 26' 6" do	do	702,900	2,888	4 2 2	Clay & Rock	Steel Tank, Concrete & brick floor, expansion joint between floor & shell
F	do	100' do 22' do	do	1,029,000	4,369	4 4 10	Clay	do do do do do do do do
F	do (2)	100' (each) do 32' 6" do	do	3,087,000	11,677	3 15 7	Do	do do do do do do do do
G	Settling Tank (1)	200' x 115' x 10' do	do	2,100,400	3,176	3 3 2	Do	Concrete vertical wall with counterforts, concrete floor
G	do (2)	100' (each) do 11' do	do	2,100,400	3,705	3 13 9	Do	do do do do do do do do
G	Service Reservoir	60' do 13' do	do	211,700	948	4 9 6	Do	Brick vertical wall, concrete floor
G	do	56' do 17' do	do	285,900	1,241	5 0 11	Granite Rock	do do do do do do do do
G	do	100' do 16' 6" do	do	750,000	£ s d 24 10 3	4 10 0	Decomposed Granite	do do do do do do do do
G	do	140' do 22' do	do	1,950,000	6,278	3 4 4	Shale & Sandstone	Concrete vertical wall do
H	Settling Tank	200' x 115' x 10' do	do	985,600	5,421	5 10 0	Clay & Shale	Brick walls backed with poor concrete, batter lining, Brick & Concrete floor
H	Service Reservoir	180' x 60' x 12' do	do	789,000	5,327	6 15 0	Do & Rock	Concrete walls, batter lining, backed with hand packed rubble, set in clay puddle, concrete floor, brick partition wall
H	Settling Tank	194' 6" x 194' 6" x 10' do	do	2,235,000	5,724	2 11 2	Do do	Concrete lining, batter lining, backed with hand packed rubble, set in clay puddle, Concrete floor
H	Service Reservoir	120' 6" x 90' 6" x 17' do	do	98,500,000	£ s d 24 10 4	0 19 1	Do do	Sides 14 to 1 pitched with stone, Puddle trench in embankment, floor lined with lime concrete
H	do	100' x 50' x 33' do	do	946,896	3,268	3 9 0	Sandstone & Rock	Only partly walled with concrete
C'	do	30' Diam. 20' do	Covered	63,200	926	14 13 0	Clay & Shale	Brick, vertical wall, concrete floor, brick dome roof
C'	do	30' do 20' do	do	63,200	936	14 16 2	Rotten Trap Rock	do do do do do do do do
I	do	27' x 27' x 5' do	Open	20,000	900	45 0 0	Clay	Cast Iron Tank, flat bottom, elevated 24' 6" on brick piers, connected by arches at top

FIG. 1.

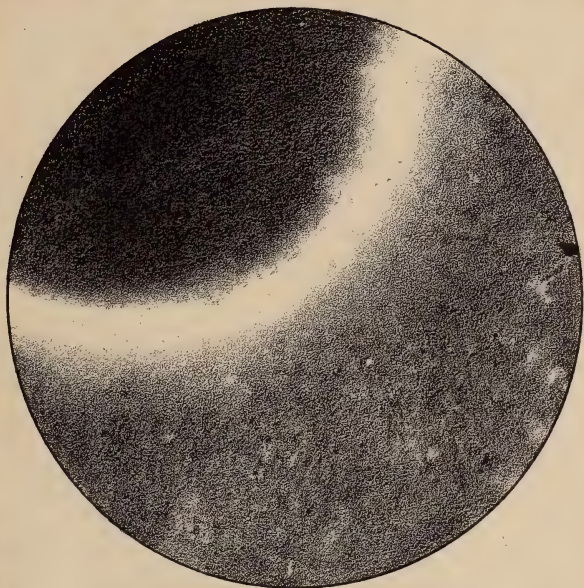
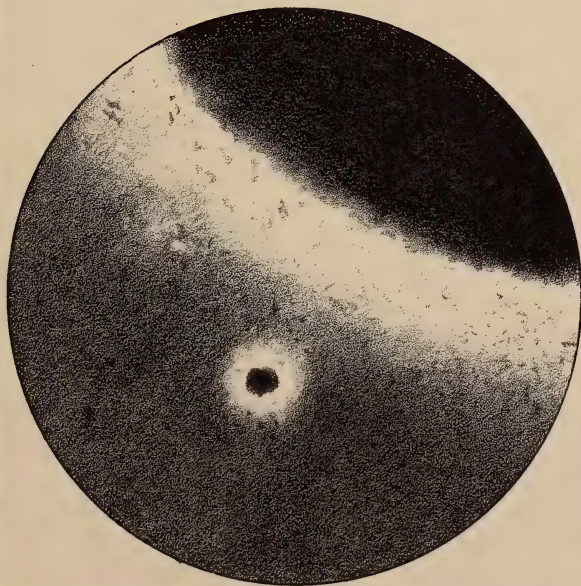


FIG. 2.



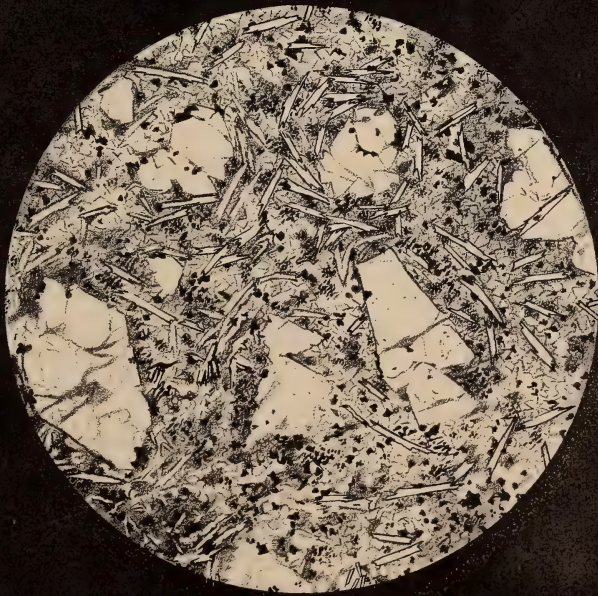
S.T. LEIGH & CO. LITH.

TACHYLYTE, CARCQAR. NEW SOUTH WALES, X 50 DIAMS.

FIG 1.



FIG 2.



S.T. LEIGH & CO. LITH.

FIG. 1, BASALT, ORANGE, NEW SOUTH WALES, X 50 DIAMS.

FIG. 2, OLIVINE BASALT, BATHURST, N. S. WALES, X 50 DIAMS.

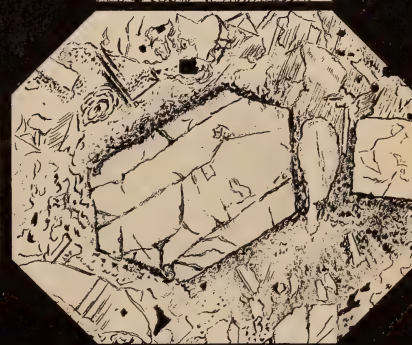
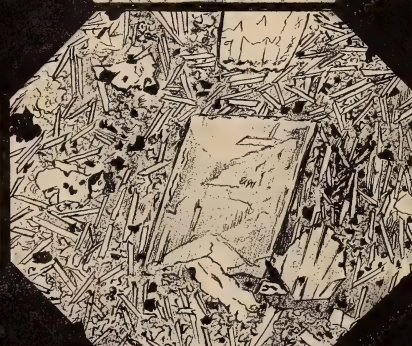
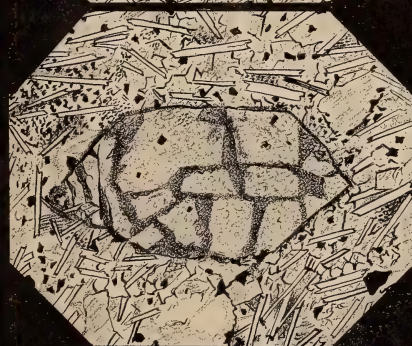
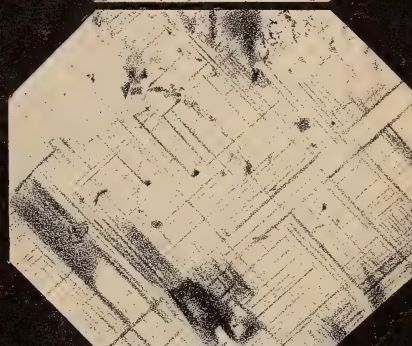
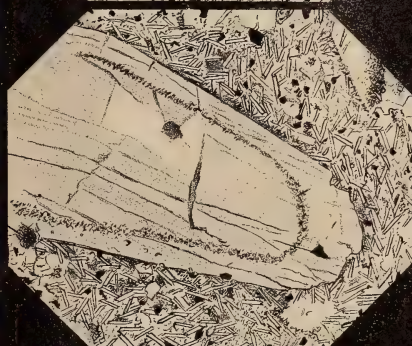
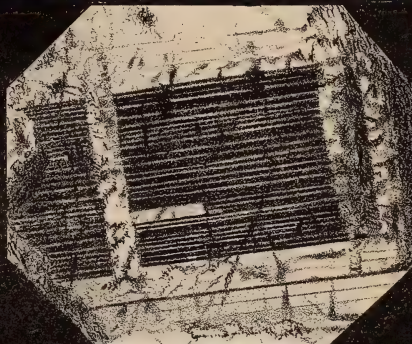
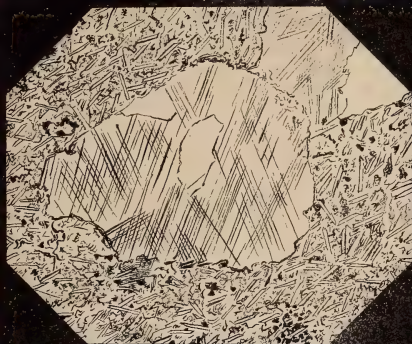


FIG. 1. CRYSTALLIZED KAOLINITE.

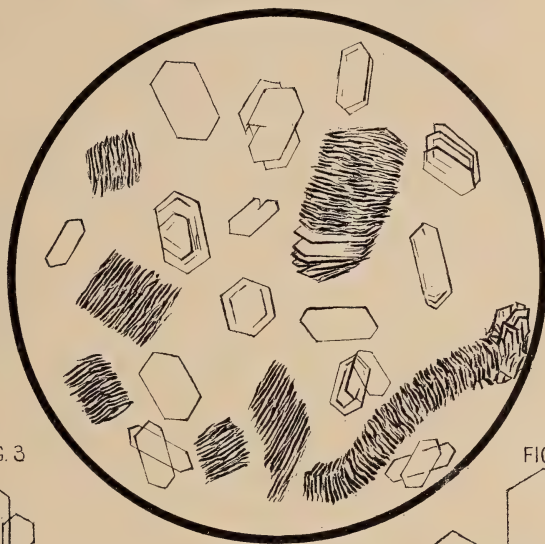


FIG. 3



FROM CLAY. GRONULLA BEACH,
PORT JACKING N^o SYDNEY.

FIG. 4



FIGURES TO SHOW CLEAVAGE, &
HOW THE CRYSTALS BREAK.



FIG. 2. AFTER HEATING WITH BLOWPIPE.
ALL MAGNIFIED ABOUT 50 DIAMETERS.

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